(54) Title: EXTRUDED POLYOLEFIN RESIN FOAM

(57) Abstract: The present invention provides thick extruded foam which is extruded polyolefin resin foam having open cells, used for cushion material and packaging material and the like, which exhibits uniform physical product properties, high expansion ratio, and uniform cell diameter. The extruded open cell foam of the present invention is an extruded foam exhibiting an open cell foaming ratio of 50% or greater, the base resin whereof is principally composed of a mixed polymer consisting of 4.5 to 75 parts by weight of component A consisting of an ethylene ionomer resin, 0.5 to 30 parts by weight of component B consisting of a polyolefin resin having a melting point exceeding 120°C, and 20 to 95 parts by weight of component C consisting of one or two or more polymers selected from a group of ethylene-propylene rubbers, styrene elastomers, and polyethylene resins having melting points of 120°C or lower (where component A + component B + component C = 100 parts by weight). Various kinds of additives such as anti-shrinking agents can be mixed in this extruded foam.

DESCRIPTION

EXTRUDED POLYOLEFIN RESIN FOAM

TECHNICAL FIELD

5   This invention relates to extruded polyolefin resin
foam used in cushion material, packaging material, sound
absorbing material, water absorbing material, anti-
vibration material, and various kinds of industrial filters,
etc.

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BACKGROUND ART

The open cell foams made of synthetic resins known to
the prior art include urethane foams, foam rubber, and
ethylene-vinyl acetate copolymer foams, etc. These foams,
15   because they are flexible and exhibit good processability,
have been used in such applications as cleaning sponges,
shock absorbing materials, cushion materials, sound
absorbing materials, and various industrial filters.
Nevertheless, applications for these open cell extruded
20   foams have been limited due to their inferiority in terms
of chemical resistance (acid resistance, alkali resistance,
etc.) and weatherability. Furthermore, urethane foams and
foam rubber are very difficult to recycle back to raw
materials, while ethylene-vinyl acetate copolymer foams are

problematic because of their large amount of foul odor

during manufacture.

Polyolefin resins, on the other hand, exhibit very

outstanding chemical resistance and weatherability, as well

5   as outstanding recyclability. Accordingly, the problems

noted above can be overcome if the open cell extruded foam

is made of a polyolefin resin.

That being so, attempts have been made before to

develop open cell polyolefin resin foams. Art is known,

10   for example, for subjecting a closed cell polyolefin resin

foam to pinhole processing to form open cell foam. However,

open cell polyolefin resin foams obtained by simply

subjecting closed cell foams made from polyethylene resin

or polypropylene resin base material to pinhole processing

15   exhibit high permanent compression set, and do not have

sufficient shock-absorbing properties to stand up under

prolonged use.

Other methods have also been reported, such as that

described in Japanese Patent Publication No. S60-55290/1985

20   which uses a mixture of low-density polyethylene and high-

density polyethylene, and that described in Japanese Patent

Application Laid-Open No. 2000-7817 which uses a mixture of

low-fluidity and high-fluidity low-density polyethylenes as

the base resin for obtaining an open cell extruded foam.

With those methods, however, foam of sufficient thickness, width, and expansion ratio are not obtained, nor do such foams exhibit adequate practical usability. Also known are open cell foams made of polyolefin resins and ionomer

5   resins. In Japanese Patent Application Laid-Open No. H10-279724/1998, for example, a foam is disclosed wherein for 0 to 50 parts by weight of a polyolefin resin are used 100 to 50 parts by weight of a costly ionomer resin. However, when foam extrusion of an open cell foam of such mixture as

10   noted above is performed, the extrusion pressure is high, wherefore heat generation at the die is severe, making it very difficult to obtain good open cell extruded foams exhibiting a high expansion ratio and high thickness. In addition, the molten resin setting temperature (hereinafter

15   called the foaming temperature) must be regulated within a narrow range during extrusion foaming in order to obtain the open cell extruded foam, making stable manufacture difficult. Also, in Japanese Patent Application Laid-Open No. 59-196384/1994, a foam wherein for 100 parts by weight

20   of a polyolefin resin, 60 to 150 parts by weight of an ionomer resin are used, but this is small rod-shaped foam having a cross-sectional area of 0.1 cm^2 or so which is used as core material in sealers used in window frames and the like, for example.

In Japanese Patent Application No. 2000-23179, an open cell extruded foam is described wherein a mixture of two or three or more polyolefin resins having different melting points is used as the base resin. More specifically, in this patent application, an open cell extruded foam is described, the main component whereof is a mixed polymer configured by a component consisting of a polyolefin resin, and a component consisting either of one or two or more polymers selected from a group made up of ethylene-α, or β unsaturated carboxylic acid copolymers (but excluding ionomers), olefin elastomers, styrene elastomers, and ethylene-vinyl acetate copolymers, or of such mixed polymer to which a heat reversible crosslinked polymer has been added.

With the resin mixture described above, the range of suitable foaming temperatures wherewith the open cell foam can be stably obtained is narrow, and, if the foaming temperature is higher than the suitable foaming temperatures, the foam contracts, making it difficult to obtain foam having the desired expansion ratio and thickness, whereas, if the foaming temperature is lower than the suitable foaming temperatures, the closed cell foaming ratio rises and the desired open cell foam is not obtained. If an attempt is made to obtain an open cell

foam of high foaming expansion ratio, moreover, the cell

wall thickness of the foam becomes thin, it becomes very

difficult to retain the shape of the open cell foamed cell

walls during extrusion foaming, and good foam is difficult

5   to obtain.

Thus, in the prior art, it has been very difficult to

stably manufacture foam exhibiting uniform physical product

properties, and to stably manufacture polyolefin resin open

cell extruded foam exhibiting high expansion ratio and high

10   open cell foaming ratio, especially thick product

exhibiting uniform physical properties.

With the foregoing in view, it is an object of the

present invention to provide extruded open cell foam of

uniform physical product properties, with a high expansion

15   ratio, and uniform cell diameter, particularly such

extruded open cell foam that is thick.

                    DISCLOSURE OF THE INVENTION

The present invention is an extruded polyolefin resin

20   open cell foam having an open cell foaming ratio of 50% or

higher. The base resin of the foam of the present

invention has as its main component a mixed polymer

consisting of 4.5 to 75 parts by weight of a component A

consisting of an ethylene ionomer resin, 0.5 to 30 parts by

weight of a component B consisting of a polyolefin resin

having a melting point exceeding 120°C, and 20 to 95 parts

by weight of a component C consisting of one or two or more

polymers selected from a group of ethylene-propylene

5   rubbers, styrene elastomers, and polyethylene resins having

melting points of 120°C or lower (where component A +

component B + component C = 100 parts by weight).

The component B consisting of the polyolefin resin

having a melting point exceeding 120°C should be one or two

10 or more mixed resins selected from among polypropylene

resin, linear low-density polyethylenes, and polyethylene

resins having a density of 940 kg/m^3 or greater.

The polyethylene resin having a melting point of 120°C

or lower in component C should be one or two or more mixed

15 resins selected from among low-density polyethylenes,

ethylene-α, or β unsaturated carboxylic acid copolymers

(but excluding ionomers), and ethylene-vinyl acetate

copolymers.

An anti-shrinking agent can be added to the base resin,

20 whereupon the amount added should be 0.1 to 15 parts by

weight for 100 parts by weight of the basic resin.

The extruded open cell foam of the present invention

should have a density of 15 to 200 kg/m^3 and thickness of

0.5 to 200 mm, which can be configured either as sheet-form

foam or plank-form foam. The shape is not limited to a

flat shape, however, and rod-shaped foam can also be

configured. The form of the rod shapes may be either one

5   with a hollow cross-section or solid cross-section, with a

density of 15 to 100 kg/m^3 and an area of cross-section

(perpendicular to direction of extrusion) of 0.7 cm^2 or

greater being preferred.

Based on the present invention, in an extruded open

10   cell foam of broad width, or an extruded open cell foam of

large thickness, having a high expansion ratio, good foam

is realized with uniform cell diameter and little partial

variation in mechanical properties. In the present

invention, furthermore, by adding the base resin configured

15   as described in the foregoing, particularly by adding a

specific amount of the polyolefin resin having a melting

point exceeding 120°C of component B, to the components A

and C, benefits are realized in that the range of suitable

foaming temperature for stably obtaining the extruded open

20   cell foam broadens, manufacture of the extruded open cell

foam is made easy, and product yield can be improved.

BEST MODE FOR CARRYING OUT THE INVENTION

The extruded polyolefin resin foam of the present invention is an extruded polyolefin resin open cell foam having an open cell foaming ratio of 50% or higher. The base resin for this extruded open cell foam has as its main

5   component a mixed polymer consisting of 4.5 to 75 parts by weight of a component A consisting of an ethylene ionomer resin, 0.5 to 30 parts by weight of a component B consisting of a polyolefin resin having a melting point exceeding 120°C, and 20 to 95 parts by weight of a

10   component C consisting of one or two or more polymers selected from a group of ethylene-propylene rubbers, styrene elastomers, and polyethylene resins having melting points of 120°C or lower (where component A + component B + component C = 100 parts by weight).

15   The mixed polymer that is the main component in the base resin configuring the extruded open cell foam of the present invention comprises 4.5 to 75 parts by weight of component A, 0.5 to 30 parts by weight of component B, and 20 to 95 parts by weight of component C (where component A

20   + component B + component C = 100 parts by weight), and the extruded open cell foam can be manufactured stably. In the interest of obtaining foam exhibiting higher expansion ratio, broad width, and high thickness, and also in the

interest of restraining heat generation caused by the high

viscosity of resin during extrusion foaming, moreover, it

is preferable that component A be 5 parts by weight or

greater but less than 50 parts by weight, that component B

5   be 1 to 30 parts by weight, and that component C be 20 to

90 parts by weight (where component A + component B +

component C = 100 parts by weight), and, in the interest of

obtaining even more outstanding foam cell uniformity and

less permanent compressive strain, it is particularly

10   preferable that the component A be 10 to 45 parts by weight,

component B 1 to 15 parts by weight, and component C 40 to

70 parts by weight (where component A + component B +

component C = 100 parts by weight).

In this invention, when the component A noted in the

15   foregoing is less than 4.5 parts by weight, a closed cell

foam is formed at a resin extrusion temperature wherewith a

foam is obtained, and the targeted foam cannot be obtained

even by making the extrusion temperature higher in an

effort to obtain open cell foam. When the component A

20   exceeds 75 parts by weight, on the other hand, heat

generation in the die becomes severe, and it is very

difficult to obtain extruded open cell foam of high

thickness and high expansion ratio.

When component B is less than 0.5 parts by weight, moreover, the shape retention effect in the cells configuring the foam becomes small and it becomes very difficult to obtain extruded open cell foam exhibiting a

5   high expansion ratio and high wall thickness having uniform physical properties, and, particularly in a thick foam, cell uniformity is lost and giant cells are generated. When component B exceeds 30 parts by weight, on the other hand, foamability is impaired, and good extruded open cell

10   foam cannot be obtained.

When component C is less than 20 parts by weight, there will be little quantity of component of low melt tension in the vicinity of the foaming temperature, making it very difficult to obtain extruded open cell foam. When

15   component C exceeds 95 parts by weight, on the other hand, closed cell foam forms readily, and it becomes very difficult to obtain extruded open cell foam.

The extruded polyolefin resin foam of the present invention has an open cell foaming ratio of 50% or higher.

20   When the open cell foaming ratio is less than 50%, certain effects manifest by the peculiar functions exhibited by the extruded open cell foam, such as restorability after repeated stress, cushioning properties, flexibility, sound absorption, water absorption, and gas permeability, are

lessened, and it becomes difficult to deal with an open

cell foam in terms of function and physical properties. By

the open cell foaming ratio of the extruded open cell foam

in the present invention, moreover, is meant not just a

5   value for a portion of the foam, but an average value for

the foam overall. Accordingly, even if in one part of the

extruded open cell foam there is a portion that falls below

the open cell foaming ratio specified in the present

invention, that is permissible so long as the average value

10 for the foam overall is equal to or higher than the open

cell foaming ratio specified in the present invention.

In the interest of making the restorability after

repeated stress, cushioning properties, flexibility, sound

absorption, water absorption, and gas permeability that are

15 properties peculiar to extruded open cell foams

particularly outstanding, the open cell foaming ratio

should be 70% or higher and preferably 80% or higher. When

the open cell foaming ratio is 70% or higher, the foam

becomes extremely soft to the touch, and clearly differs

20 from foam having an open cell foaming ratio below 70%.

The open cell foaming ratio in the present invention

is measured as noted below, in accordance with ASTM D-2856-

70 (procedure C).

The true volume Vx (cm³) of the measurement specimen
is found using an air pycnometer, the apparent volume Va
(cm³) of the measurement specimen is found from the outer
dimensions thereof, and the open cell foaming ratio (%) is
5   calculated by formula 1 below. By true volume Vx is meant
the sum of the volume of the resin and the volume of the
closed cell portion in the measurement specimen.

Formula 1

Open cell foaming ratio (%) = {(Va -Vx)/(Va - W/ρ)}× 100
10   where W is the weight (g) of the measurement specimen, and
ρ is the density (g/cm³) of the base resin configuring the
foam.

The dimensions of the measurement specimen is 25 mm
longitudinally, 25 mm laterally, and 40 mm in thickness.
15   The extruded foam of the present invention, as described
subsequently, can be configured in a sheet-form, plank-form,
or rod-shaped form, in every which case samples are formed
by cutting to the prescribed dimensions. In such cases, if
a specimen having dimensions matching the dimensions of the
20   measurement specimen described above cannot be obtained
from one cutout sample, then multiple cutout samples are
combined to prepare one measurement specimen. If, for
example, one cutout sample were 25 mm longitudinally, 25 mm

laterally, and 20 mm in thickness, then two cutout samples

having these dimensions would be stacked together to

prepare a measurement specimen measuring 25 mm

longitudinally, 25 mm laterally, and 40 mm in thickness.

5   Multiple sampling sites for the measurement specimens

are established (preferably 10 or more sites), the open

cell foaming ratio for each of those multiple measurement

specimens obtained is found and the average value thereof

calculated, and that average value is made the open cell

10 foaming ratio of the extruded foam of the present invention.

The main component in the base resin of the extruded

open cell foam of the present invention is a mixed polymer

configured of a component A consisting of an ethylene

ionomer resin, a component B consisting of a polyolefin

15 resin having a melting point exceeding 120°C, and a

component C consisting of one or two or more polymers

selected from a group of ethylene-propylene rubbers,

styrene elastomers, and polyethylene resins having melting

points of 120°C or lower. In the present invention,

20 furthermore, by saying that the mixed polymer is the main

component in the base resin is meant that the mixed polymer

is contained in an amount that at least exceeds 50 wt.% of

the base resin configuring the extruded open cell foam, but

preferably 75 wt.% or more, and even more preferably 90 wt.% or more.

Accordingly, besides the mixed polymer consisting of the components A, B, and C noted above, a conventionally known resin or rubber or the like can be mixed, within a range of up to but not including 50 wt.%, in the base resin of the extruded open cell foam of the present invention, among which those with which a polymer composition of a denatured polyolefin polymer such as an ethylene-maleic acid anhydride-ethyl acrylate terpolymer or ethylene-butene-1 copolymer and a hydroxyl group containing polymer such as hydroxyl group ended polybutadiene hydrogenation product, methacrylic acid 2-hydroxyethyl graft ethylene-butene-1 copolymer, or low molecular weight polyolefin polyol are mixed, wherewith the crosslinked structure is weakened by heating, having so-called heat reversible crosslinked structures, being particularly preferred because therewith compressive elasticity is enhanced, and outstanding extruded open cell foam exhibiting little permanent compressive strain is formed.

By the ethylene ionomer resin configuring component A of the base resin in the present invention is meant a metal salt crosslinked compound of a copolymer between an ethylene monomer and an α or β unsaturated carboxylic acid

such as acrylic acid, methacrylic acid, itaconic acid,
maleic acid, fumaric acid, or cinnamic acid, etc. Examples
of such metal salts that may be cited include alkali metal
salts, alkali earth metal salts, typical metal salts, and
5   transition metal salts. Metal salt crosslinked compounds
of these polymers form a type of crosslinked structure
between molecules by the ionic bonding force of the metal
ions, whereby physical properties like those of crosslinked
molecules are exhibited at room temperature, but
10   processability like that of a non-crosslinked polymer is
exhibited at the high temperatures where extrusion molding
is possible.

Specific examples of such ethylene ionomer resins that
may be cited include ionomer resins wherein crosslinking is
15   effected by metal ions between the molecules of such
copolymers as ethylene-acrylic acid copolymer, ethylene-
acrylic acid-methylacrylate copolymer, ethylene-acrylic
acid-ethylacrylate copolymer, ethylene-methacrylic acid-
methylacrylate copolymer, ethylene-methacrylic acid-
20   ethylacrylate copolymer, or ethylene-methacrylic acid
copolymer, etc. Nor is the ethylene ionomer resin limited
to a single resin, but may be one wherein two or more
ethylene ionomer resins have been mixed.

The component B comprising the polyolefin resin having a melting point exceeding 120°C that configures the base resin in the present invention may be a polyethylene resin, polypropylene resin, or polybutene resin or the like. For the polyethylene resin noted here, polyethylenes having a density of 940 kg/m^3 or greater, and linear low-density polyethylenes and the like may be cited. For the polyolefin resin in component B, of the resins noted above, either one type or a mixture of two or more types of polypropylene resin linear low-density polyethylene or polyethylene having a density of 940 kg/m^3 or greater is preferable. By the component B, the range of suitable foaming temperatures during extraction foaming is broadened and it becomes possible to stably manufacture good extruded open cell foam.

The polyethylene resin having a melting point exceeding 120°C that configures the component B noted earlier is an ethylene homo-polymer or a copolymer between ethylene, on the one hand, and an α-olefin having 3 to 12 carbons or the like, on the other, wherein the ethylene component is contained in an amount of 50 wt.% or more. Specific examples thereof that may be cited include high-density polyethylenes, medium-density polyethylenes, linear

low-density polyethylenes, ethylene-anhydrous maleic acid

copolymers, ethylene-butene copolymers, ethylene-vinyl

alcohols, and ethylene-glycidyl methacrylates, etc,

respectively having a melting point exceeding 120°C.

5 Furthermore, the polyethylene resin is not limited to a

single resin but may be one wherein two or more types of

polyethylene resin have been mixed.

By a polypropylene resin having a melting point

exceeding 120°C configuring the component B is meant a

10 propylene homo-polymer or a copolymer between propylene, on

the one hand, and another monomer component on the other,

wherein the propylene component is contained in an amount

that is 50 wt.% or greater. That copolymer may be a random

copolymer, a block copolymer, or a graft copolymer.

15 Examples of the other monomer component configuring the

copolymer that may be cited include ethylene, 1-butene,

isobutylene, 1-pentene, 3-methyl-1-butene, 1-hexene, 3,4-

dimethyl-1-butene, 1-pentene, and 3-methyl-1-hexene, etc.

Furthermore, the polypropylene resin is not limited to a

20 single resin but may be one wherein two or more

polypropylene resins have been mixed.

For the component B in the present invention, moreover,

not only may a polyethylene resin, polypropylene resin, or

polybutene resin or the like be used singly, but a mixture

of two or more types thereof may be used.

The component C configuring the base resin in the

present invention is one or two or more types of polymer

5 selected from among the group of ethylene-propylene rubbers,

styrene elastomers, and polyethylene resins having a

melting point of 120°C or lower.

The polyethylene resin having a melting point of 120°

or lower configuring the component C is an ethylene homo-

10 polymer or a copolymer between ethylene, on the one hand,

and an α-olefin having 3 to 12 carbons or the like, on the

other, wherein the ethylene component is contained in an

amount of 50 wt.% or greater. Specific examples thereof

that may be cited include low-density polyethylenes,

15 medium-density polyethylenes, linear low-density

polyethylenes, very low-density polyethylenes, ethylene-

anhydrous maleic acid copolymers, ethylene-butene

copolymers, ethylene-vinyl alcohols, ethylene-glycidyl

methacrylates, ethylene-α or β unsaturated carboxylic acid

20 copolymers (but excluding ionomers), and ethylene-vinyl

acetate copolymers, having a melting point of 120°C or

lower. Furthermore, this polyethylene resin is not limited

to a single resin, but use may be made of one wherein two

or more types have been mixed. Among these polyethylene

resins, one type or a mixed resin of two or more types

selected from among the low-density polyethylenes,

ethylene-α or β unsaturated carboxylic acid copolymers (but

5   excluding ionomers), and ethylene-vinyl acetate copolymers

is particularly to be preferred.

For the α, or β unsaturated carboxylic acid component

of the ethylene-α, or β unsaturated carboxylic acid

copolymer in the polyethylene resins having a melting point

10   of 120°C or lower, acrylic acid, methacrylic acid, itaconic

acid, maleic acid, fumaric acid, and cinnamic acid,

together with alkyl esters and the like thereof may be

cited, of which, from the perspective of general-

purposefulness, acrylic acid, methacrylic acid, and alkyl

15   esters thereof are to be preferred.

The ethylene-α or β unsaturated carboxylic acids noted

above are obtained by copolymerizing ethylene with the α or

β unsaturated carboxylic acid component. More specifically,

ethylene-acrylic acid copolymers, ethylene-methyl acrylate

20   copolymers, ethylene-ethyl acrylate copolymers, ethylene-

methacrylic acid copolymers, ethylene-methyl methacrylate

copolymers, and ethylene-ethyl methacrylate copolymers and

the like may be cited. The content ratio for the α or β

unsaturated carboxylic acid in the ethylene-α or β

unsaturated carboxylic acid copolymer noted above should be

2 to 50 wt.%, with 10 to 40 wt.% being particularly to be

preferred.

5   For the ethylene-vinyl acetate copolymer in the

polyethylene resin having a melting point of 120°C or lower,

the vinyl acetate content prefers to be 5 to 50 wt.%.

Because the difference in viscosity with the component A is

appropriate, extruded open cell foam can be obtained with

10   even greater stability in the extraction process.

In the present invention, the melting point of the

polyolefin resin configuring the component B and of the

polyethylene resin configuring the component C is made the

temperature at the apex of a peak found from test pieces

15   subjected to a certain heat treatment according to the heat

flux DSC curve based on JIS K7121 (1987). When two or more

peaks appear, the temperature at the apex of the main peak

having the largest peak area is made the melting point.

The density of the polyethylene resin of the component B is

20   found according to JIS K7112 (1980).

Citable examples for the styrene propylene rubber

configuring the component C include ethylene-propylene

copolymers and ethylene-propylene-diene copolymers.

Citable examples for the ethylene elastomer

configuring the component C include styrene-butadiene-

styrene block copolymers (SBS), styrene-isoprene-styrene

block copolymers (SIS), styrene-ethylene copolymers,

5   styrene-ethylene-propylene copolymers, SBS hydrogenation

product, and SIS hydrogenation product, etc.

In the present invention, furthermore, various kinds

of additives such as anti-shrinking agents, foam regulators,

weather-resisting agents, UV radiation absorbers, UV

10 radiation reflectors, infrared radiation absorbers,

infrared radiation reflectors, flame retardants, lubricants,

colorants, thermal stabilizers, anti-oxidants,

crystallization nucleating agents, inorganic fillers, and

rubbers, etc., can be suitably mixed into the base resin as

15 necessary.

In the present invention, among the additives noted

above, in particular, it is preferable that 0.1 to 15 parts

by weight of an anti-shrinking agent be added to 100 parts

by weight of the base resin because thereby it is possible

20 to obtain good foam, especially foam exhibiting a high

expansion ratio and high thickness.

Citable examples of this anti-shrinking agent include

esters of a fatty acid having 10 or more but preferably

from 15 to 25 carbons and a polyvalent alcohol having 3 to

7 hydroxyl groups, fatty acid amines having 10 or more but preferably from 15 to 25 carbons, and fatty acid amides having 10 or more but preferably from 15 to 25 carbons, etc.

For the fatty acid having 10 or more carbons in the

5 anti-shrinking agent noted above, stearic acid, oleic acid, lauric acid, behenic acid, lignoceric acid, cerotic acid, heptaconic acid, montanic acid, melissic acid, and laccelic acid, etc., may be cited, while for the polyvalent alcohol having 3 to 7 hydroxyl groups, glycerin, diglycerin,

10 triglycerin, erythritol, arabitol, xylitol, mannitol, sorbitol, and sorbitan may be cited. For the anti-shrinking agent, moreover, a mixture of two or more anti-shrinking agents may also be used.

Specific examples of anti-shrinking agents that may be

15 cited include glyceryl monostearate, glyceryl monobehenate, glyceryl distearate, glyceryl tristearate, polyoxyethylene myristyl amine, polyoxyethylene palmitin amine, polyoxyethylene stearyl amine, lauric acid amide, myristic acid amide, palmitic acid amide, and stearic acid amide,

20 etc.

Examples of the foam regulator noted above that may be cited include fine powdered forms of such inorganic substances as talc, silica, and clay, etc., and such carbonate or bicarbonate salts as alkali metal salts of

polyvalent carboxylic acid such as sodium hydrogen tartrate, potassium hydrogen succinate, sodium citrate, potassium citrate, sodium bicarbonate, sodium carbonate, and sodium oxalate, etc., which prefer to be added in an amount of

5   0.01 to 10 parts by weight to 100 parts by weight of the base resin.

For the foaming agent used in the manufacture of the extruded open cell foam of the present invention, either a physical foaming agent or a decomposing type foaming agent

10   can be used, but the use of a physical foaming agent is preferred in order to obtain extruded open cell foam of high expansion ratio. For a physical foaming agent, fatty hydrocarbons such as propane, normal butane, isobutane, normal pentane, isopentane, normal hexane, isohexane, and

15   cyclohexane, etc, such chloro-hydrocarbons as methyl chloride and ethyl chloride, such fluoro-hydrocarbons as 1,1,1,2-tetrafluoroethane and 1,1-difluoroethane, etc and such inorganic substances as carbon dioxide, nitrogen, and water, etc may be cited. For a decomposing type foaming

20   agent, azodicarbonamide and the like may be cited. The foaming agents noted above can be used in mixtures of two or more, and a decomposing type foaming agent may be used together with a physical foaming agent and thus serve also to regulate the cell diameter.

The extruded open cell foam of the present invention prefers to have a density of 15 to 200 kg/m³ and a thickness of 0.5 to 200 mm, configured either as sheet-form foam or plank-form foam. Nor is this foam limited to a

5   flat form, but may be configured as rod-shaped foam. The form of the rod-shaped foam may be cross-sectionally hollow or cross-sectionally solid. When the extruded open cell foam of the present invention is sheet-form foam, the sheet-form foam prefers to have a density of 15 to 200

10   kg/m³ and better still 15 to 60 kg/m³, and a thickness of 0.5 mm or greater but less than 10 mm. The width of the sheet-form foam prefers to be 45 cm or greater, and more preferably with 90 cm or greater, and with an upper limit for the width of 190 cm or so. Sheet-form foam so

15   configured exhibits outstanding flexibility and makes ideal packaging material. It is also possible to subject this foam to such processing as bag fabrication or thermoforming or the like, for use as bags, fruit trays, or other containers. This foam can be used in a wide variety of

20   applications including partitioning materials obtained by performing stamping processing or cutting processing on laminated sheet wherein materials exhibiting shape retention such as other polypropylene resin foam sheet or polystyrene resin foam sheet are integrally laminated, and

packaging containers such as fruit packaging materials or precision instrument packaging containers exhibiting high shock-absorption obtained by thermoforming such laminated sheet.

5   When the extruded open cell foam of the present invention is plank-form foam, the density prefers to be 15 to 100 kg/m³ and the thickness 10 to 200 mm. The width of the plank-form foam should be at least 8 cm, with 25 cm or greater being preferable, and with an upper limit on the

10   width of 150 cm or so. Plank-form foam so configured is ideal for shock absorbing pads, sound absorbing materials, and cushion materials and the like. In particular, when compared to the soft urethane open cell foam used conventionally as a cushion material, the plank-form foam

15   of the present invention exhibits mild compressive strain (the deforming speed being slower than that of ordinary soft urethane), which property is an outstanding property deserving particular mention for applications such as cushion material. This plank-form foam can be made into

20   any desired shape, to suit the application, by stamping processing or cutting processing.

When the extruded open cell foam of the present invention is rod-shaped foam, the density prefers to be 15 to 100 kg/m³, and the area of the cross-section

perpendicular to the direction of extrusion prefers to be 0.7 cm^2 or greater and more preferably from 1 to 900 cm^2. When the rod-shaped foam has a hollow cross-section, it is configured in a cylindrical shape, whereas when the rod-

5   shaped foam has a solid cross-section, it is configured in a columnar shape. By forming cut creases in the longitudinal direction of the cylindrically shaped foam, use as shock-protecting material for pipes and columns and the like is possible, while the foam of the columnar shape

10   can be used as packing and sealing material, taking advantage of the delayed restoration property (the fact that the speed of shape restoration after compression deformation is slower than that of ordinary soft urethane) peculiar to such foam. It is also easy to obtain cushion

15   material and the like of large volume by joining the side surfaces of many rod-shaped foam bodies together.

In the present invention, the thickness and density of the extruded open cell foam are measured as described below. That is, for the thickness of the extruded open cell foam,

20   the thickness of the foam is measured at ten points at equal intervals from one edge to the other edge in the width dimension, and the arithmetic mean of those ten points is taken. For the density of the extruded open cell foam, the weight (g) of a test piece that is 5 cm

longitudinally, 5 cm across, and the thickness of the foam
is measured, the volume (cm^3) of the test piece is next
found from the outer dimensions of the test piece, and the
quotient obtained by dividing the weight (g) of the test

5   piece by the volume thereof is converted to kg/m^3 units.

The extruded open cell foam of the present invention
can be obtained by taking the base resin noted earlier,
such additives as anti-shrinking agents or foaming
regulators such as talc which are added as necessary,

10 supplying those to an extruder, subjecting those materials
to melting under heating and kneading, then supplying a
foaming agent and forming a foaming molten resin mixture,
then regulating the extrusion resin temperature, pressure
inside the extrusion die, and discharge volume, etc., and

15 extruding the mixture from the die attached to the tip of
the extruder into a low-pressure region and causing foaming.
For the method of mixing the components A, B, and C and the
additives, a known method can be adopted such as the method
of dry-blending the mixture components, or the method of

20 using a screw feeder of the like to introduce each of the
mixture components from an extruder raw material supply
port and mixing them together inside the extruder.

By selecting the die attached to the tip of the
extruder according to the shape of the foam intended,

moreover, extruded open cell foam of various shapes can be manufactured, whether sheet-form foam, plank-form foam, or rod-shaped foam, etc. If a circular die is attached, for example, sheet-form foam can be obtained, whereas if a flat

5   die is attached, plank-form foam can be obtained, and if a die having a hole matching the cross-sectional shape of the rod bodies is attached, rod-shaped foam can be obtained that is cylindrical or columnar or the like, but if a many-holed die is attached, cord-shaped foam or foam having a

10   wide perpendicular cross-section at right angles to the direction of extrusion wherein multiple rod-shaped foam body side surfaces are fused together can be obtained, and if dies of different shape are attached then foam bodies having different cross-sectional shapes can be manufactured.

15   Also, if necessary, an apparatus (accumulator) may be installed wherewith the foaming molten resin mixture is accumulated between the extruder and the die or inside the die under conditions of high temperature and high pressure, and, after a prescribed volume has accumulated, that

20   mixture is extruded from the die all at once using a movable ram. By installing an accumulator, the discharge speed can be increased dramatically, wherefore, even if the extruder is small, the foam of the present invention having

high expansion ratio and high thickness can be obtained, especially foam that is plank-form or rod-shaped.

In the present invention, extruded open cell foam wherein the open cell foaming ratio is 50% or greater can be formed, as described above, by supplying the base resin and foaming agent and the like to an extruder, heating, melting, and kneading those materials to form a foaming molten resin mixture, and then adjusting the extrusion resin temperature to be within a suitable foaming temperature range. That is, the foaming molten resin mixture wherein the extrusion resin temperature has been adjusted to be within a suitable foaming temperature range exhibits visco-elasticity that resists the foaming power of the foaming agent, so that the mixture foams uniformly, and, at the stage where cell walls are formed, the component C consisting of the polyolefin resin having a melting point of 120°C or lower and the like cannot follow the stretch of the component A and component B noted earlier, the softening point is low compared to the component A and component B, and a decline in visco-elasticity of component C causes the cell walls to rupture, whereupon open cell foaming occurs evenly. Even if cell wall destruction occurs, caused by the reduced visco-elasticity of component C, the cell shapes themselves are preserved, due to the

sufficient visco-elasticity of the component A. It is further thought that, in the present invention, the component B is also contained in the base resin, wherefore the molten viscosity enhancing effect due to the

5   crystallization of the component B after foaming leads to an enhancement in the rigidity of the cells that configure the foam, that in turn results in reinforcing the cell shape retaining function of the component A, as a consequence whereof the suitable foaming temperature range

10 wherein the extruded open cell foam is stably obtained is broadened.

Specifically, the extrusion resin temperature prefers to be adjusted within a range of 100 to 140°C, and more preferably to within a range of 110 to 130°C. When the

15 extrusion resin temperature is below 100°C, the elastic force of the component A and the component C at the time of foaming will be too strong, whereupon it has possibility that extruded open cell foam having a high expansion ratio can not obtain it.

20   When the extrusion resin temperature exceeds 140°C, on the other hand, it has possibility that such problems arising as that the obtained foam will tend to shrink, or that giant cells will tend to be produced in the foam.

The open cell foaming ratio of the extruded open cell foam can be regulated by such methods as that of selecting the polymer in the component C in the base resin described earlier, that of adding a lubricant to the polymer of the

5   component C, or that of adjusting the viscosity of the component C.

In the present invention, after manufacturing the extruded open cell foam having an open cell foaming ratio of 50% or greater, the open cell foaming ratio of the foam

10   can be raised further by a secondary process such as one employing the method of subjecting the foam to a pin-hole process, piercing it with needles or the like, or one employing the method of destroying cell walls by expansion under heat, or by compression or the like.

15   The present invention is now described in even greater detail with the citation of embodiments.

The densities, melt flow rates, and melting points of the resins and polymers used are noted in Table 1.

The values given in Table 1 for the melt flow rate

20   (MFR) were measured at a temperature of 190°C, under a load of 21.18 N, according to JIS K7210 (1976).

Table 1

	Resin	Product Name	Manufacturer	Density (kg/m³)	MFR (g/10min)	Melting point (°C)
Resin A	Ionomer	Himilan AM7316	DuPont-Mitsui Polychemicals	950	1.3	74.6
Resin B	HDPE	Idemitsu DH 210JZ	Idemitsu Petrochemical	968	5.0	133.6
Resin C	LLDPE	ULTZEX 3550R	Mitsui Petrochemical Industries	935	4.5	123.5
Resin D	PP	Idemitsu PP J700GP	Idemitsu Petrochemical	900	8.0	162.5
Resin E	PP	SUN-ALLOMER PM620A	SunAllomer	900	8.0	149.0
Resin F	LDPE	SUMIKATHENE F101-1	Sumitomo Chemical	922	0.3	110.3
Resin G	LDPE	NUC 8008	Nippon Unicar	917	4.7	107.9
Resin H	EMMA	Acryft WK307	Sumitomo Chemical	940	7.0	76.4
Resin I	EMMA	Acryft WK402	Sumitomo Chemical	940	20.0	73.9
Resin J	VLDPE	EXCELLEN VL EUL731	Sumitomo Chemical	895	10.0	108.6
Resin K	EMAA	NUCREL AN4318	DuPont-Mitsui Polychemicals	940	31.0	78.1

Notes:

Ionomer: Ethylene-methacrylic acid-acrylic-acid ester
           terpolymer metal salts cross-linked compound

HDPE: High-density polyethylene

LLDPE: Linear low-density polyethylene

PP: Polypropylene homopolymer

LDPE: Low-density polyethylene

EMMA: Ethylene-methyl methacrylate copolymer (ethylene

content = 75%)

VLDPE: Linear very low-density polyethylene

5 EMAA: Ethylene-methacrylic acid copolymer (ethylene

content = 92%)

Embodiment 1

Raw material obtained by mixing 100 parts by weight of
10 a mixed resin into which were mixed 38 parts by weight of
"resin A," 5 parts by weight of "resin B," and 57 parts by
weight of "resin G," 2 parts by weight of a foaming
regulator master batch in which 5 parts by weight of sodium
citrate and 10 parts by weight of talc were mixed for 100
15 parts by weight of the low-density polyethylene "resin G,"
and 10 parts by weight of an anti-shrinking agent master
batch in which 12 parts by weight of glyceryl monostearate
were mixed for 100 parts by weight of the low-density
polyethylene "resin G," was supplied to a tandem type
20 extruder having a first extruder with a caliber of 50 mm
and a second extruder with a caliber of 65 mm connected by
a crossbar passage, heated, and kneaded to make a molten
resin, after which isobutane was pressure-injected and
kneaded into the resin inside the extruder, as a physical

foaming agent, at a ratio of 8 parts by weight to 100 parts
by weight of the mixed resin, to make the foaming molten
material. Next, the molten material melted and kneaded
inside the extruder was extruded from flat dies having a
5   slit width of 30 mm and slit interval of 3 mm to yield
plank-form extruded open cell foam.

    The density, open cell foaming ratio, average cell
diameter, thickness, and width of the foam so obtained were
measured, respectively, and the results indicated,
10   respectively, in Table 2.

Cell Uniformity Evaluation:

○ ··· No giant cells or crushed cells are observed in the
         center part of the cross-section of the foam, and
         cell shape is uniform.

15   Δ ··· Cell shape in the cross-section of the foam is
         unevenness.

   × ··· Giant cells or crushed cells are observed in the
         center part of the cross-section of the foam.

Manufacturing Stability Evaluation:

20   ○ ··· Density variation across a temperature width of 3°C
         or more in the foaming temperature range is less
         than 5 kg/m^3, and the variation in open cell foaming

ratio across a temperature width of 3°C or more in
the foaming temperature range is 5% or lower.

× ··· Everything not meeting the criteria noted above.

The average cell diameters given in the table are
5   values arrived at by drawing a straight line crossing the
entire thickness of the foam in the thickness dimension,
based on photographs obtained from cross-sections
perpendicular to the foam extrusion direction or width
dimension, counting the number of cells intersecting that
10   straight line, and dividing the foam thickness (mm) by the
number of cells so obtained.

Table 2

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE (Resin A / Resin B / Resin G)	117	38.8	100	1.28	33.4	100.0	○	○
	118	38.5	100	1.30	33.8	100.2	○	
	119	36.2	100	1.25	35.3	98.4	○	
	120	37.7	100	1.18	35.3	98.3	○	
	121	35.9	100	1.28	35.9	98.3	○	

Embodiment 2

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by mixing 38 parts by weight of "resin A," 5 parts by weight of "resin B," and 57 parts by weight of "resin H." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 3.

Table 3

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/EMMA (Resin A / Resin B / Resin H)	118	46.2	98	0.93	30.1	97.2	○	
	119	46.7	97	0.95	29.9	95.2	○	○
	120	48.7	98	0.90	29.4	92.4	○	
	121	49.3	99	0.94	29.0	92.2	○	

Embodiment 3

    Extruded plank-form extruded open cell foam was
obtained with the same conditions as in Embodiment 1 except
in that 100 parts by weight of mixed resin were made by
5   mixing 38 parts by weight of "resin A," 5 parts by weight
of "resin B," 28.5 parts by weight of "resin F," and 28.5
parts by weight of "resin I." The density, open cell
foaming ratio, average cell diameter, thickness, and width
of the foam so obtained were measured, respectively, the
10 foam cross-sectional cell uniformity and manufacturing
stability were evaluated as noted above, and the results
indicated, respectively, in Table 4.

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Table 4

Base Resin	Foaming Conditions	Physical Properties of Foam						Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m^3)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)			
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	117	34.4	96	1.33	39.1	104.0	○	
	118	34.3	97	1.30	39.6	101.2	○	
	119	36.8	100	1.23	37.8	101.4	○	○
	120	36.0	96	1.25	37.0	99.4	○	
	121	35.6	98	1.32	36.8	96.2	○	

Embodiment 4

Raw material obtained by mixing 100 parts by weight of
a mixed resin into which were mixed 29 parts by weight of
"resin A," 5 parts by weight of "resin B," 38 parts by
5   weight of "resin F," and 28 parts by weight of "resin I," 2
parts by weight of a foaming regulator master batch in
which 5 parts by weight of sodium citrate and 10 parts by
weight of talc were mixed for 100 parts by weight of the
low-density polyethylene "resin G," and 10 parts by weight
10   of an anti-shrinking agent master batch in which 12 parts
by weight of glyceryl monostearate were mixed for 100 parts
by weight of the low-density polyethylene "resin G," was
supplied to a tandem type extruder having a first extruder
with a caliber of 50 mm and a second extruder with a
15   caliber of 65 mm connected by a crossbar passage, heated,
and kneaded to make a molten resin, after which isobutane
was pressure-injected and kneaded inside the extruder, as a
physical foaming agent, at a ratio of 5.8 parts by weight
to 100 parts by weight of the mixed resin, the foaming
20   molten material obtained was filled into and accumulated
inside an accumulator having a caliber of 90 mm connected
downstream from the second extruder, after which the
foaming molten material was extruded all at once, by moving
a movable ram, from the interior of the accumulator,

through flat dies having a slit width of 90 mm and slit interval of 3mm, to yield plank-form extruded open cell foam.

5   The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 5.

Table 5

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	115	43.7	97	1.27	45.9	267.6	○	○
	116	44.7	96	1.29	45.5	268.4	○	
	117	44.9	98	1.32	45.3	263.0	○	
	118	45.2	98	1.36	45.0	267.4	○	

Embodiment 5

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by

5   mixing 33.3 parts by weight of "resin A," 16.7 parts by weight of "resin B," 25 parts by weight of "resin F," and 25 parts by weight of "resin I." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the

10   foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 6.

Table 6

Base Resin	Foaming Conditions		Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)			
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	121	44.8	99	1.20	28.1	93.0	○	○
	122	43.5	98	1.17	29.3	92.2	○	
	123	41.0	99	0.98	30.2	90.2	○	

Embodiment 6

Extruded plank-form extruded open cell foam was
obtained with the same conditions as in Embodiment 1 except
in that 100 parts by weight of mixed resin were made by
5 mixing 40 parts by weight of "resin A," 3 parts by weight
of "resin B," 28.5 parts by weight of "resin F," and 28.5
parts by weight of "resin I", and 8.7 parts by weight of
isobutane were pressure-injected and kneaded into 100 parts
by weight of the mixed resin inside the extruder. The
10 density, open cell foaming ratio, average cell diameter,
thickness, and width of the foam so obtained were measured,
respectively, the foam cross-sectional cell uniformity and
manufacturing stability were evaluated as noted above, and
the results indicated, respectively, in Table 7.

Table 7

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	120	31.0	95	1.32	43.5	107.6	○	○
	121	31.2	96	1.35	43.3	105.5	○	
	122	33.3	99	1.28	42.2	103.0	○	
	123	33.8	100	1.20	41.7	101.4	○	

Embodiment 7

        Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin B," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin I", and 8.7 parts by weight of

isobutane were pressure-injected and kneaded into 100 parts

by weight of the mixed resin inside the extruder. The

10 density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 8.

Table 8

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMA (Resin A / Resin B / Resin F / Resin I)	119	31.4	96	1.39	41.7	109.0	○	
	120	30.9	96	1.42	42.2	108.4	○	
	121	31.1	97	1.34	42.6	106.4	○	○
	122	31.0	99	1.36	43.3	106.2	○	
	123	31.8	99	1.36	42.4	105.4	○	

With Embodiment 7, in a foaming temperature range of

5°C or higher, the change in density is less than 5 kg/m^3,

and the change in open cell foaming ratio is 5% or less,

outstanding manufacturing stability is exhibited, no cell

5   crushing is seen in the center of the foam cross-section

such as that seen in Comparative Example 3 (described

subsequently), and outstanding cell uniformity is exhibited.

It is seen that, with Embodiment 7, extruded open cell foam

of low density and high foaming efficiency is obtained,

10 even with the same amount of foaming agent as in

Comparative Example 3.

Embodiment 8

Extruded plank-form extruded open cell foam was

15 obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin C," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin I", and 8.7 parts by weight of

20 isobutane were pressure-injected and kneaded into 100 parts

by weight of the mixed resin inside the extruder. The

density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 9.

Table 9

Base Resin	Mixed Resin Type	Foaming Conditions Foaming Temperature (°C)	Physical Properties of Foam Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)	Cell Uniformity	Manufacturing Stability
Ionomer /LLDPE/LDPE /EMA (Resin A / Resin C / Resin F / Resin I)		118	41.0	96	1.20	41.0	105.2	○	
		119	42.0	97	1.27	42.0	104.8	○	
		120	42.9	95	1.34	42.9	103.0	○	○
		121	40.3	100	1.22	40.3	102.0	○	

Embodiment 9

    Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by

5 mixing 38 parts by weight of "resin A," 5 parts by weight of "resin D," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin I", and 8.7 parts by weight of isobutane were pressure-injected and kneaded into 100 parts by weight of the mixed resin inside the extruder. The

10 density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 10.

Table 10

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /PP/LDPE/ EMMA (Resin A / Resin D / Resin F / Resin I)	119	34.8	97	1.15	38.9	105.0	○	○
	120	34.3	99	1.13	38.6	105.0	○	
	121	36.8	100	1.04	37.1	104.5	○	

Embodiment 10

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by
5   mixing 38 parts by weight of "resin A," 5 parts by weight of "resin E," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin I", and 8.7 parts by weight of isobutane were pressure-injected and kneaded into 100 parts by weight of the mixed resin inside the extruder. The
10 density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 11.

Table 11

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /PP/LDPE/ EMMA (Resin A / Resin E / Resin F / Resin I)	118	40.5	96	1.02	32.0	102.2	○	○
	119	38.3	100	1.08	33.9	100.0	○	
	120	37.9	100	1.12	34.4	100.2	○	

Embodiment 11

      Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 29 parts by weight of "resin A," 5 parts by weight

of "resin B," 37 parts by weight of "resin F," and 29 parts

by weight of "resin G." The density, open cell foaming

ratio, average cell diameter, thickness, and width of the

foam so obtained were measured, respectively, the foam

10 cross-sectional cell uniformity and manufacturing stability

were evaluated as noted above, and the results indicated,

respectively, in Table 12.

Table 12

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /LDPE (Resin A / Resin B / Resin F / Resin G)	117	42.9	92	1.23	29.2	99.0	O	O
	118	43.8	93	1.19	28.9	98.0	O	
	119	47.6	96	1.12	26.9	94.0	O	

Embodiment 12

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by

5 mixing 38 parts by weight of "resin A," 5 parts by weight of "resin B," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin J." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the

10 foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 13.

Table 13

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /VLDPE (Resin A / Resin B / Resin F / Resin J)	119	34.8	92	1.27	36.8	97.4	○	○
	120	35.2	93	1.23	36.3	96.2	○	
	121	39.0	96	1.17	33.7	94.2	○	

Embodiment 13

5

10

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by mixing 38 parts by weight of "resin A," 5 parts by weight of "resin B," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin K." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 14.

Table 14

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMAA (Resin A / Resin B / Resin F / Resin K)	115	33.4	67	0.81	39.5	110.0	○	○
	116	33.1	68	0.79	39.7	110.2	○	
	117	32.9	68	0.82	39.8	108.2	○	
	118	33.2	68	0.95	40.2	108.0	○	
	119	33.0	68	0.93	40.4	108.0	○	
	120	33.4	70	0.90	40.3	106.2	○	
	121	33.6	71	0.92	40.6	104.0	○	

Comparative Example 1

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by
5   mixing 43 parts by weight of "resin A," and 57 parts by weight of "resin G." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were
10 evaluated as noted above, and the results indicated, respectively, in Table 15.

Table 15

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (℃)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE (Resin A / Resin G)	115	37.7	100	1.41	34.9	101.4	△	○
	116	38.6	100	1.38	36.7	100.0	△	
	117	36.5	100	1.43	37.5	99.6	△	

With Comparative Example 1, in a foaming temperature

range of 3°C or higher, the change in density is less than

5 kg/m³, and the change in open cell foaming ratio is 5% or

less. However, with Embodiment 1 that temperature range is

5   broadened to 5°C or greater, and Embodiment 1 is recognized

as exhibiting more outstanding manufacturing stability.

Also, although the foam obtained in Comparative Example 1

is usable as a product, cell unevenness is observed very

locally in the foam cross-section, wherefore the foam of

10   Embodiment 1 exhibits more outstanding cell uniformity.

Comparative Example 2

Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

15   in that 100 parts by weight of mixed resin were made by

mixing 43 parts by weight of "resin A," 28.5 parts by

weight of "resin F," and 28.5 parts by weight of "resin I."

The density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

20   respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 16.

Table 16

Base Resin	Foaming Conditions		Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)			
Ionomer /LDPE/EMA (Resin A / Resin F / Resin I)	115	36.0	86	1.26	40.9	102.4	○	○	×
	116	41.9	98	0.98	36.1	100.4	○	
	117	50.4	100	–	32.6	91.2	×	
	118	60.8	100	–	27.3	84.0	×	

("–" in table indicates no measurement made)

Comparative Example 2 is a comparative example for Embodiment 3. With Comparative Example 2, in a foaming temperature range of 3°C, the change in density is 5 kg/m³ or greater, manufacturing stability is lacking, and cell 5 crushing was observed in the center of the cross-section of the foam obtained at a foaming temperature of 117°C or higher.

Comparative Example 3

10   Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by mixing 43 parts by weight of "resin A," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin I," 15 and 8.7 parts by weight of isobutane were pressure injected and kneaded into 100 parts by weight of the mixed resin inside the extruder. The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross- 20 sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 17.

Table 17

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE/EMMA (Resin A / Resin F / Resin I)	117	31.8	76	1.68	43.9	102.0	○	
	118	34.5	85	1.42	37.2	101.4	○	×
	119	41.7	100	1.03	34.0	91.8	○	
	120	41.4	100	–	34.9	88.0	×	
	121	49.4	100	–	31.6	82.0	×	

("–" in table indicates no measurement made)

Comparative Example 3 is a comparative example for Embodiment 7. With Comparative Example 3, in a foaming temperature range of 3°C, the change in density is 5 kg/m³ or greater, manufacturing stability is lacking, and cell crushing was observed in the center of the cross-section of the foam obtained at a foaming temperature of 120°C or higher.

Comparative Example 4

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by mixing 34 parts by weight of "resin A," 37 parts by weight of "resin F," and 29 parts by weight of "resin G." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 18.

Table 18

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE/LDPE (Resin A / Resin F / Resin G)	116	30.6	38	1.89	39.3	100.6	○	×
	117	40.2	78	—	33.4	97.0	△	
	118	48.2	95	—	25.5	92.2	△	
	119	57.6	100	—	19.5	80.6	△	

("—" in table indicates no measurement made)

Comparative Example 4 is a comparative example for Embodiment 11. With Comparative Example 4, in a foaming temperature range of 3°C, the change in density exceeds 5 kg/m^3, manufacturing stability is lacking, and portions of

5   cell unevenness were observed in the cross-section of the foam obtained at a foaming temperature of 117°C or higher.

Comparative Example 5

Extruded plank-form extruded open cell foam was

10   obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by mixing 43 parts by weight of "resin A," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin J." The density, open cell foaming ratio, average cell diameter,

15   thickness, and width of the foam so obtained were measured, respectively, the foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 19.

Table 19

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE/VLDPE (Resin A / Resin F / Resin J)	117	34.7	92	1.47	39.3	98.0	O	X
	118	42.4	98	0.90	33.4	90.0	O	
	119	60.3	100	0.62	25.5	68.6	X	

Comparative Example 5 is a comparative example for

Embodiment 12. With Comparative Example 5, in a foaming

temperature range of 3°C, the change in density is 5 kg/m^3

or greater, manufacturing stability is lacking, and cell

5   crushing was observed in the center of the cross-section of

the foam obtained at a foaming temperature of 119°C or

higher.

Comparative Example 6

10   An attempt was made to obtain rod-shaped extruded open

cell foam with the same conditions as in Embodiment 1

except in that 100 parts by weight of mixed resin were made

by mixing 5 parts by weight of "resin B," 67 parts by

weight of "resin F," and 28 parts by weight of "resin H,"

15   and in that the die was made 4mm ϕ rod die, but no foam was

obtained.

Below, the compressive strengths of the foams obtained

in Embodiments 6 to 9 and Comparative Example 3 are given

in Table 20, and the defection set by constant compression

20   and defection set by repeated compressions of the foams

obtained in Embodiments 6 to 10 and Comparative Example 3

are given in Tables 21 and 22, respectively. The methods

of testing for compressive strength and permanent

compressive strain were as described below.

Compressive strength:

Static compression tests were performed in accordance

5   with JIS Z0234 (1976) Method A. The dimensions of the test

pieces were made 50 mm longitudinally x 50 mm across x the

thickness of the foam and the load speed was made 10

mm/minute. After compressing the test piece to 80% of its

thickness, the compression was released at the same speed

10 as the load speed, and measurement was concluded at the

point in time where the compressive stress became 0 Pa, to

yield a stress-strain curve. The loads at the time of 5%

compression and at the time of 25% compression,

respectively, were read from the curve obtained, and the 5%

15 compressive strength and 25% compressive strength were

calculated therefrom.

Defection set by constant compression:

Except in that the conditions of the test atmosphere

were made 23°C temperature and 50% relative humidity,

20 defection set by constant compression tests were performed

according to JIS K6401 (1980). The dimensions of the test

pieces were made 50 mm longitudinally x 50 mm across x the

thickness of the foam. The test piece was compressed to

50% and left standing in that condition for 22 hours, after

which the compression was released. The thickness of the

test piece was then measured, 30 minutes later and 24 hours

later, respectively, and the percentage of defection set by

5   constant compression was calculated.

Defection set by repeated compressions:

Except in that the conditions of the test atmosphere

were made 23°C temperature and 50% relative humidity,

defection set by repeated compressions tests were performed

10   according to JIS K6401 (1980). The dimensions of the test

pieces were made 50 mm longitudinally × 50 mm across × the

thickness of the foam. The test piece was subjected to

80,000 continuously repeated compressions to 50% of the

thickness thereof, at a speed of 60 revolution/minute.

15   Then the thickness of the test piece was measured, 30

minutes and 24 hours after the compression was released,

respectively, and the percentage of defection set by

repeated compressions was calculated therefrom.

Table 20

	5% Compressive Strength (kPa)	25% Compressive Strength (kPa)
Embodiment 6	5.16	9.41
Embodiment 7	6.09	10.36
Embodiment 8	4.32	8.21
Embodiment 9	5.91	10.37
Comparative Example 3	4.45	7.66

5

Table 21

	Percentage of defection set by constant compression After 30 Minutes(%)	Percentage of defection set by constant compression After 24 Hours(%)
Embodiment 6	6.8	2.0
Embodiment 7	7.4	2.2
Embodiment 8	4.4	2.3
Embodiment 9	6.1	1.8
Embodiment 10	4.9	1.1
Comparative Example 3	3.4	1.0

Table 22

	Percentage of defection set by repeated compressions After 30 Minutes(%)	Percentage of defection set by repeated compressions After 24 Hours(%)
Embodiment 6	10.7	3.8
Embodiment 7	10.9	4.5
Embodiment 8	9.0	3.1
Embodiment 9	8.3	2.6
Embodiment 10	7.8	2.4
Comparative Example 3	5.4	2.8

5 <u>INDUSTRIAL APPLICABILITY</u>

The extruded polyolefin resin foam of the present invention exhibits a high expansion ratio, uniform cell diameter, and outstanding mechanical properties, and is well suited for use as cushion material, packaging material, 10 sound absorbing material, water absorbing material, anti-vibration material, and various types of industrial filter.

CLAIMS

1. An extruded polyolefin resin foam, characterized in that said extruded polyolefin resin foam is an extruded foam exhibiting an open cell ratio of 50% or greater, and that base resin thereof is principally composed of a mixed polymer consisting of 4.5 to 75 parts by weight of component A consisting of an ethylene ionomer resin, 0.5 to 30 parts by weight of component B consisting of a polyolefin resin having a melting point exceeding 120°C, and 20 to 95 parts by weight of component C consisting of one or two or more polymers selected from a group of ethylene-propylene rubbers, styrene elastomers, and polyethylene resins having melting points of 120°C or lower (where component A + component B + component C = 100 parts by weight).

2. The extruded polyolefin resin foam according to claim 1, characterized in that said component B consisting of a polyolefin resin having a melting point exceeding 120°C is one type or a mixed resin of two or more types selected from among polypropylene resin, linear low-density polyethylenes, and polyethylene resins having a density of 940 kg/m³ or greater.

3.   The extruded polyolefin resin foam according to
claim 1, characterized in that said polyethylene resin
having a melting point of 120°C or lower in said component
C is one type or a mixed resin of two or more types
5   selected from among low-density polyethylenes, ethylene-α
or β unsaturated carboxylic acid copolymers (but excluding
ionomers), and ethylene-vinyl acetate copolymers.

4.   The extruded polyolefin resin foam according to
claim 1, characterized in that 0.1 to 15 parts by weight of
10 an anti-shrinking agent are added to 100 parts by weight of
said base resin.

5.   The extruded polyolefin resin foam according to
claim 1 or claim 4, characterized in that said extruded
foam has a density of 15 to 200 kg/m^3 and a thickness of
15 0.5 to 200 mm.

6.   The extruded polyolefin resin foam according to
claim 1 or claim 4, characterized in that said extruded
foam is sheet-form foam or plank-form foam.

7.   The extruded polyolefin resin foam according to
20 claim 1 or claim 4, characterized in that said extruded
foam is rod-shaped foam having a density of 15 to 100 kg/m^3,
and area of vertical cross-section thereof orthogonal to
direction of extrusion being 0.7 cm^2 or greater.

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(54) Title: EXTRUDED POLYOLEFIN RESIN FOAM

(57) Abstract: The present invention provides thick extruded foam which is extruded polyolefin resin foam having open cells, used for cushion material and packaging material and the like, which exhibits uniform physical product properties, high expansion ratio, and uniform cell diameter. The extruded open cell foam of the present invention is an extruded foam exhibiting an open cell foaming ratio of 50% or greater, the base resin whereof is principally composed of a mixed polymer consisting of 4.5 to 75 parts by weight of component A consisting of an ethylene ionomer resin, 0.5 to 30 parts by weight of component B consisting of a polyolefin resin having a melting point exceeding 120°C, and 20 to 95 parts by weight of component C consisting of one or two or more polymers selected from a group of ethylene-propylene rubbers, styrene elastomers, and polyethylene resins having melting points of 120°C or lower (where component A + component B + component C = 100 parts by weight). Various kinds of additives such as anti-shrinking agents can be mixed in this extruded foam.

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7   C08J9/14   C08J9/00   //C08L23/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7   C08J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, CHEM ABS Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 636 473 A (ALKOR GMBH) 1 February 1995 (1995-02-01) page 7; example 1; table claims	1-7
A	US 5 110 842 A (TAKEDA MASASHI ET AL) 5 May 1992 (1992-05-05) table 1A claims	1-7

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Oudot, R

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INTERNATIONAL SEARCH REPORT

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(74) Agent: HOSOI, Isamu; Ginzachikuyoutei Bldg. 8F., 19-3, Ginza 8-chome, Chuo-ku, Tokyo 104-0061 (JP).

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WO 02/18482 A2

<u>DESCRIPTION</u>

EXTRUDED POLYOLEFIN RESIN FOAM

<u>TECHNICAL FIELD</u>

5   This invention relates to extruded polyolefin resin foam used in cushion material, packaging material, sound absorbing material, water absorbing material, anti-vibration material, and various kinds of industrial filters, etc.

10

<u>BACKGROUND ART</u>

The open cell foams made of synthetic resins known to the prior art include urethane foams, foam rubber, and ethylene-vinyl acetate copolymer foams, etc. These foams, 15 because they are flexible and exhibit good processability, have been used in such applications as cleaning sponges, shock absorbing materials, cushion materials, sound absorbing materials, and various industrial filters. Nevertheless, applications for these open cell extruded 20 foams have been limited due to their inferiority in terms of chemical resistance (acid resistance, alkali resistance, etc.) and weatherability. Furthermore, urethane foams and foam rubber are very difficult to recycle back to raw materials, while ethylene-vinyl acetate copolymer foams are

problematic because of their large amount of foul odor during manufacture.

Polyolefin resins, on the other hand, exhibit very outstanding chemical resistance and weatherability, as well
5 as outstanding recyclability. Accordingly, the problems noted above can be overcome if the open cell extruded foam is made of a polyolefin resin.

That being so, attempts have been made before to develop open cell polyolefin resin foams. Art is known,
10 for example, for subjecting a closed cell polyolefin resin foam to pinhole processing to form open cell foam. However, open cell polyolefin resin foams obtained by simply subjecting closed cell foams made from polyethylene resin or polypropylene resin base material to pinhole processing
15 exhibit high permanent compression set, and do not have sufficient shock-absorbing properties to stand up under prolonged use.

Other methods have also been reported, such as that described in Japanese Patent Publication No. S60-55290/1985
20 which uses a mixture of low-density polyethylene and high-density polyethylene, and that described in Japanese Patent Application Laid-Open No. 2000-7817 which uses a mixture of low-fluidity and high-fluidity low-density polyethylenes as the base resin for obtaining an open cell extruded foam.

With those methods, however, foam of sufficient thickness,

width, and expansion ratio are not obtained, nor do such

foams exhibit adequate practical usability. Also known are

open cell foams made of polyolefin resins and ionomer

5 resins. In Japanese Patent Application Laid-Open No. H10-

279724/1998, for example, a foam is disclosed wherein for 0

to 50 parts by weight of a polyolefin resin are used 100 to

50 parts by weight of a costly ionomer resin. However,

when foam extrusion of an open cell foam of such mixture as

10 noted above is performed, the extrusion pressure is high,

wherefore heat generation at the die is severe, making it

very difficult to obtain good open cell extruded foams

exhibiting a high expansion ratio and high thickness. In

addition, the molten resin setting temperature (hereinafter

15 called the foaming temperature) must be regulated within a

narrow range during extrusion foaming in order to obtain

the open cell extruded foam, making stable manufacture

difficult. Also, in Japanese Patent Application Laid-Open

No. 59-196384/1994, a foam wherein for 100 parts by weight

20 of a polyolefin resin, 60 to 150 parts by weight of an

ionomer resin are used, but this is small rod-shaped foam

having a cross-sectional area of 0.1 cm^2 or so which is

used as core material in sealers used in window frames and

the like, for example.

In Japanese Patent Application No. 2000-23179, an open
cell extruded foam is described wherein a mixture of two or
three or more polyolefin resins having different melting
points is used as the base resin. More specifically, in
5   this patent application, an open cell extruded foam is
described, the main component whereof is a mixed polymer
configured by a component consisting of a polyolefin resin,
and a component consisting either of one or two or more
polymers selected from a group made up of ethylene-α, or β
10   unsaturated carboxylic acid copolymers (but excluding
ionomers), olefin elastomers, styrene elastomers, and
ethylene-vinyl acetate copolymers, or of such mixed polymer
to which a heat reversible crosslinked polymer has been
added.

15   With the resin mixture described above, the range of
suitable foaming temperatures wherewith the open cell foam
can be stably obtained is narrow, and, if the foaming
temperature is higher than the suitable foaming
temperatures, the foam contracts, making it difficult to
20   obtain foam having the desired expansion ratio and
thickness, whereas, if the foaming temperature is lower
than the suitable foaming temperatures, the closed cell
foaming ratio rises and the desired open cell foam is not
obtained. If an attempt is made to obtain an open cell

foam of high foaming expansion ratio, moreover, the cell
wall thickness of the foam becomes thin, it becomes very
difficult to retain the shape of the open cell foamed cell
walls during extrusion foaming, and good foam is difficult
5   to obtain.

Thus, in the prior art, it has been very difficult to
stably manufacture foam exhibiting uniform physical product
properties, and to stably manufacture polyolefin resin open
cell extruded foam exhibiting high expansion ratio and high
10   open cell foaming ratio, especially thick product
exhibiting uniform physical properties.

With the foregoing in view, it is an object of the
present invention to provide extruded open cell foam of
uniform physical product properties, with a high expansion
15   ratio, and uniform cell diameter, particularly such
extruded open cell foam that is thick.

DISCLOSURE OF THE INVENTION

The present invention is an extruded polyolefin resin
20   open cell foam having an open cell foaming ratio of 50% or
higher. The base resin of the foam of the present
invention has as its main component a mixed polymer
consisting of 4.5 to 75 parts by weight of a component A
consisting of an ethylene ionomer resin, 0.5 to 30 parts by

weight of a component B consisting of a polyolefin resin

having a melting point exceeding 120°C, and 20 to 95 parts

by weight of a component C consisting of one or two or more

polymers selected from a group of ethylene-propylene

5   rubbers, styrene elastomers, and polyethylene resins having

melting points of 120°C or lower (where component A +

component B + component C = 100 parts by weight).

The component B consisting of the polyolefin resin

having a melting point exceeding 120°C should be one or two

10   or more mixed resins selected from among polypropylene

resin, linear low-density polyethylenes, and polyethylene

resins having a density of 940 kg/m^3 or greater.

The polyethylene resin having a melting point of 120°C

or lower in component C should be one or two or more mixed

15   resins selected from among low-density polyethylenes,

ethylene-α, or β unsaturated carboxylic acid copolymers

(but excluding ionomers), and ethylene-vinyl acetate

copolymers.

An anti-shrinking agent can be added to the base resin,

20   whereupon the amount added should be 0.1 to 15 parts by

weight for 100 parts by weight of the basic resin.

The extruded open cell foam of the present invention

should have a density of 15 to 200 kg/m^3 and thickness of

0.5 to 200 mm, which can be configured either as sheet-form

foam or plank-form foam. The shape is not limited to a

flat shape, however, and rod-shaped foam can also be

configured. The form of the rod shapes may be either one

5   with a hollow cross-section or solid cross-section, with a

density of 15 to 100 kg/m^3 and an area of cross-section

(perpendicular to direction of extrusion) of 0.7 cm^2 or

greater being preferred.

Based on the present invention, in an extruded open

10   cell foam of broad width, or an extruded open cell foam of

large thickness, having a high expansion ratio, good foam

is realized with uniform cell diameter and little partial

variation in mechanical properties. In the present

invention, furthermore, by adding the base resin configured

15   as described in the foregoing, particularly by adding a

specific amount of the polyolefin resin having a melting

point exceeding 120°C of component B, to the components A

and C, benefits are realized in that the range of suitable

foaming temperature for stably obtaining the extruded open

20   cell foam broadens, manufacture of the extruded open cell

foam is made easy, and product yield can be improved.

BEST MODE FOR CARRYING OUT THE INVENTION

The extruded polyolefin resin foam of the present
invention is an extruded polyolefin resin open cell foam
having an open cell foaming ratio of 50% or higher. The
base resin for this extruded open cell foam has as its main

5   component a mixed polymer consisting of 4.5 to 75 parts by
weight of a component A consisting of an ethylene ionomer
resin, 0.5 to 30 parts by weight of a component B
consisting of a polyolefin resin having a melting point
exceeding 120°C, and 20 to 95 parts by weight of a

10   component C consisting of one or two or more polymers
selected from a group of ethylene-propylene rubbers,
styrene elastomers, and polyethylene resins having melting
points of 120°C or lower (where component A + component B +
component C = 100 parts by weight).

15   The mixed polymer that is the main component in the
base resin configuring the extruded open cell foam of the
present invention comprises 4.5 to 75 parts by weight of
component A, 0.5 to 30 parts by weight of component B, and
20 to 95 parts by weight of component C (where component A

20   + component B + component C = 100 parts by weight), and the
extruded open cell foam can be manufactured stably. In the
interest of obtaining foam exhibiting higher expansion
ratio, broad width, and high thickness, and also in the

interest of restraining heat generation caused by the high

viscosity of resin during extrusion foaming, moreover, it

is preferable that component A be 5 parts by weight or

greater but less than 50 parts by weight, that component B

5   be 1 to 30 parts by weight, and that component C be 20 to

90 parts by weight (where component A + component B +

component C = 100 parts by weight), and, in the interest of

obtaining even more outstanding foam cell uniformity and

less permanent compressive strain, it is particularly

10 preferable that the component A be 10 to 45 parts by weight,

component B 1 to 15 parts by weight, and component C 40 to

70 parts by weight (where component A + component B +

component C = 100 parts by weight).

    In this invention, when the component A noted in the

15 foregoing is less than 4.5 parts by weight, a closed cell

foam is formed at a resin extrusion temperature wherewith a

foam is obtained, and the targeted foam cannot be obtained

even by making the extrusion temperature higher in an

effort to obtain open cell foam. When the component A

20 exceeds 75 parts by weight, on the other hand, heat

generation in the die becomes severe, and it is very

difficult to obtain extruded open cell foam of high

thickness and high expansion ratio.

When component B is less than 0.5 parts by weight,

moreover, the shape retention effect in the cells

configuring the foam becomes small and it becomes very

difficult to obtain extruded open cell foam exhibiting a

5   high expansion ratio and high wall thickness having uniform

physical properties, and, particularly in a thick foam,

cell uniformity is lost and giant cells are generated.

When component B exceeds 30 parts by weight, on the other

hand, foamability is impaired, and good extruded open cell

10   foam cannot be obtained.

When component C is less than 20 parts by weight,

there will be little quantity of component of low melt

tension in the vicinity of the foaming temperature, making

it very difficult to obtain extruded open cell foam. When

15   component C exceeds 95 parts by weight, on the other hand,

closed cell foam forms readily, and it becomes very

difficult to obtain extruded open cell foam.

The extruded polyolefin resin foam of the present

invention has an open cell foaming ratio of 50% or higher.

20   When the open cell foaming ratio is less than 50%, certain

effects manifest by the peculiar functions exhibited by the

extruded open cell foam, such as restorability after

repeated stress, cushioning properties, flexibility, sound

absorption, water absorption, and gas permeability, are

lessened, and it becomes difficult to deal with an open cell foam in terms of function and physical properties. By the open cell foaming ratio of the extruded open cell foam in the present invention, moreover, is meant not just a

5 value for a portion of the foam, but an average value for the foam overall. Accordingly, even if in one part of the extruded open cell foam there is a portion that falls below the open cell foaming ratio specified in the present invention, that is permissible so long as the average value

10 for the foam overall is equal to or higher than the open cell foaming ratio specified in the present invention.

In the interest of making the restorability after repeated stress, cushioning properties, flexibility, sound absorption, water absorption, and gas permeability that are

15 properties peculiar to extruded open cell foams particularly outstanding, the open cell foaming ratio should be 70% or higher and preferably 80% or higher. When the open cell foaming ratio is 70% or higher, the foam becomes extremely soft to the touch, and clearly differs

20 from foam having an open cell foaming ratio below 70%.

The open cell foaming ratio in the present invention is measured as noted below, in accordance with ASTM D-2856-70 (procedure C).

The true volume Vx (cm^3) of the measurement specimen
is found using an air pycnometer, the apparent volume Va
(cm^3) of the measurement specimen is found from the outer
dimensions thereof, and the open cell foaming ratio (%) is

5   calculated by formula 1 below. By true volume Vx is meant
the sum of the volume of the resin and the volume of the
closed cell portion in the measurement specimen.

Formula 1

Open cell foaming ratio (%) = {(Va -Vx)/(Va - W/ρ)}× 100

10   where W is the weight (g) of the measurement specimen, and
ρ is the density (g/cm^3) of the base resin configuring the
foam.

The dimensions of the measurement specimen is 25 mm
longitudinally, 25 mm laterally, and 40 mm in thickness.

15   The extruded foam of the present invention, as described
subsequently, can be configured in a sheet-form, plank-form,
or rod-shaped form, in every which case samples are formed
by cutting to the prescribed dimensions. In such cases, if
a specimen having dimensions matching the dimensions of the

20   measurement specimen described above cannot be obtained
from one cutout sample, then multiple cutout samples are
combined to prepare one measurement specimen. If, for
example, one cutout sample were 25 mm longitudinally, 25 mm

laterally, and 20 mm in thickness, then two cutout samples

having these dimensions would be stacked together to

prepare a measurement specimen measuring 25 mm

longitudinally, 25 mm laterally, and 40 mm in thickness.

5   Multiple sampling sites for the measurement specimens

are established (preferably 10 or more sites), the open

cell foaming ratio for each of those multiple measurement

specimens obtained is found and the average value thereof

calculated, and that average value is made the open cell

10   foaming ratio of the extruded foam of the present invention.

The main component in the base resin of the extruded

open cell foam of the present invention is a mixed polymer

configured of a component A consisting of an ethylene

ionomer resin, a component B consisting of a polyolefin

15   resin having a melting point exceeding 120°C, and a

component C consisting of one or two or more polymers

selected from a group of ethylene-propylene rubbers,

styrene elastomers, and polyethylene resins having melting

points of 120°C or lower. In the present invention,

20   furthermore, by saying that the mixed polymer is the main

component in the base resin is meant that the mixed polymer

is contained in an amount that at least exceeds 50 wt.% of

the base resin configuring the extruded open cell foam, but

preferably 75 wt.% or more, and even more preferably 90
wt.% or more.

Accordingly, besides the mixed polymer consisting of
the components A, B, and C noted above, a conventionally
5   known resin or rubber or the like can be mixed, within a
range of up to but not including 50 wt.%, in the base resin
of the extruded open cell foam of the present invention,
among which those with which a polymer composition of a
denatured polyolefin polymer such as an ethylene-maleic
10 acid anhydride-ethyl acrylate terpolymer or ethylene-
butene-1 copolymer and a hydroxyl group containing polymer
such as hydroxyl group ended polybutadiene hydrogenation
product, methacrylic acid 2-hydroxyethyl graft ethylene-
butene-1 copolymer, or low molecular weight polyolefin
15 polyol are mixed, wherewith the crosslinked structure is
weakened by heating, having so-called heat reversible
crosslinked structures, being particularly preferred
because therewith compressive elasticity is enhanced, and
outstanding extruded open cell foam exhibiting little
20 permanent compressive strain is formed.

By the ethylene ionomer resin configuring component A
of the base resin in the present invention is meant a metal
salt crosslinked compound of a copolymer between an
ethylene monomer and an α or β unsaturated carboxylic acid

such as acrylic acid, methacrylic acid, itaconic acid,

maleic acid, fumaric acid, or cinnamic acid, etc. Examples

of such metal salts that may be cited include alkali metal

salts, alkali earth metal salts, typical metal salts, and

5   transition metal salts. Metal salt crosslinked compounds

of these polymers form a type of crosslinked structure

between molecules by the ionic bonding force of the metal

ions, whereby physical properties like those of crosslinked

molecules are exhibited at room temperature, but

10   processability like that of a non-crosslinked polymer is

exhibited at the high temperatures where extrusion molding

is possible.

Specific examples of such ethylene ionomer resins that

may be cited include ionomer resins wherein crosslinking is

15   effected by metal ions between the molecules of such

copolymers as ethylene-acrylic acid copolymer, ethylene-

acrylic acid-methylacrylate copolymer, ethylene-acrylic

acid-ethylacrylate copolymer, ethylene-methacrylic acid-

methylacrylate copolymer, ethylene-methacrylic acid-

20   ethylacrylate copolymer, or ethylene-methacrylic acid

copolymer, etc. Nor is the ethylene ionomer resin limited

to a single resin, but may be one wherein two or more

ethylene ionomer resins have been mixed.

The component B comprising the polyolefin resin having

a melting point exceeding 120°C that configures the base

resin in the present invention may be a polyethylene resin,

polypropylene resin, or polybutene resin or the like. For

5   the polyethylene resin noted here, polyethylenes having a

density of 940 kg/m^3 or greater, and linear low-density

polyethylenes and the like may be cited. For the

polyolefin resin in component B, of the resins noted above,

either one type or a mixture of two or more types of

10 polypropylene resin linear low-density polyethylene or

polyethylene having a density of 940 kg/m^3 or greater is

preferable. By the component B, the range of suitable

foaming temperatures during extraction foaming is broadened

and it becomes possible to stably manufacture good extruded

15 open cell foam.

The polyethylene resin having a melting point

exceeding 120°C that configures the component B noted

earlier is an ethylene homo-polymer or a copolymer between

ethylene, on the one hand, and an α-olefin having 3 to 12

20 carbons or the like, on the other, wherein the ethylene

component is contained in an amount of 50 wt.% or more.

Specific examples thereof that may be cited include high-

density polyethylenes, medium-density polyethylenes, linear

low-density polyethylenes, ethylene-anhydrous maleic acid

copolymers, ethylene-butene copolymers, ethylene-vinyl

alcohols, and ethylene-glycidyl methacrylates, etc,

respectively having a melting point exceeding 120°C.

5   Furthermore, the polyethylene resin is not limited to a

single resin but may be one wherein two or more types of

polyethylene resin have been mixed.

       By a polypropylene resin having a melting point

exceeding 120°C configuring the component B is meant a

10   propylene homo-polymer or a copolymer between propylene, on

the one hand, and another monomer component on the other,

wherein the propylene component is contained in an amount

that is 50 wt.% or greater. That copolymer may be a random

copolymer, a block copolymer, or a graft copolymer.

15   Examples of the other monomer component configuring the

copolymer that may be cited include ethylene, 1-butene,

isobutylene, 1-pentene, 3-methyl-1-butene, 1-hexene, 3,4-

dimethyl-1-butene, 1-pentene, and 3-methyl-1-hexene, etc.

Furthermore, the polypropylene resin is not limited to a

20   single resin but may be one wherein two or more

polypropylene resins have been mixed.

       For the component B in the present invention, moreover,

not only may a polyethylene resin, polypropylene resin, or

polybutene resin or the like be used singly, but a mixture of two or more types thereof may be used.

The component C configuring the base resin in the present invention is one or two or more types of polymer

5 selected from among the group of ethylene-propylene rubbers, styrene elastomers, and polyethylene resins having a melting point of 120°C or lower.

The polyethylene resin having a melting point of 120° or lower configuring the component C is an ethylene homo-

10 polymer or a copolymer between ethylene, on the one hand, and an α-olefin having 3 to 12 carbons or the like, on the other, wherein the ethylene component is contained in an amount of 50 wt.% or greater. Specific examples thereof that may be cited include low-density polyethylenes,

15 medium-density polyethylenes, linear low-density polyethylenes, very low-density polyethylenes, ethylene-anhydrous maleic acid copolymers, ethylene-butene copolymers, ethylene-vinyl alcohols, ethylene-glycidyl methacrylates, ethylene-α or β unsaturated carboxylic acid

20 copolymers (but excluding ionomers), and ethylene-vinyl acetate copolymers, having a melting point of 120°C or lower. Furthermore, this polyethylene resin is not limited to a single resin, but use may be made of one wherein two

or more types have been mixed. Among these polyethylene

resins, one type or a mixed resin of two or more types

selected from among the low-density polyethylenes,

ethylene-α or β unsaturated carboxylic acid copolymers (but

5   excluding ionomers), and ethylene-vinyl acetate copolymers

is particularly to be preferred.

For the α, or β unsaturated carboxylic acid component

of the ethylene-α, or β unsaturated carboxylic acid

copolymer in the polyethylene resins having a melting point

10   of 120°C or lower, acrylic acid, methacrylic acid, itaconic

acid, maleic acid, fumaric acid, and cinnamic acid,

together with alkyl esters and the like thereof may be

cited, of which, from the perspective of general-

purposefulness, acrylic acid, methacrylic acid, and alkyl

15   esters thereof are to be preferred.

The ethylene-α or β unsaturated carboxylic acids noted

above are obtained by copolymerizing ethylene with the α or

β unsaturated carboxylic acid component. More specifically,

ethylene-acrylic acid copolymers, ethylene-methyl acrylate

20   copolymers, ethylene-ethyl acrylate copolymers, ethylene-

methacrylic acid copolymers, ethylene-methyl methacrylate

copolymers, and ethylene-ethyl methacrylate copolymers and

the like may be cited. The content ratio for the α or β

unsaturated carboxylic acid in the ethylene-α or β

unsaturated carboxylic acid copolymer noted above should be

2 to 50 wt.%, with 10 to 40 wt.% being particularly to be

preferred.

5   For the ethylene-vinyl acetate copolymer in the

polyethylene resin having a melting point of 120°C or lower,

the vinyl acetate content prefers to be 5 to 50 wt.%.

Because the difference in viscosity with the component A is

appropriate, extruded open cell foam can be obtained with

10   even greater stability in the extraction process.

In the present invention, the melting point of the

polyolefin resin configuring the component B and of the

polyethylene resin configuring the component C is made the

temperature at the apex of a peak found from test pieces

15   subjected to a certain heat treatment according to the heat

flux DSC curve based on JIS K7121 (1987). When two or more

peaks appear, the temperature at the apex of the main peak

having the largest peak area is made the melting point.

The density of the polyethylene resin of the component B is

20   found according to JIS K7112 (1980).

Citable examples for the ethylene propylene rubber

configuring the component C include ethylene-propylene

copolymers and ethylene-propylene-diene copolymers.

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Citable examples for the styrene elastomer configuring the component C include styrene-butadiene-styrene block copolymers (SBS), styrene-isoprene-styrene block copolymers (SIS), styrene-ethylene copolymers, styrene-ethylene-

5   propylene copolymers, SBS hydrogenation product, and SIS hydrogenation product, etc.

In the present invention, furthermore, various kinds of additives such as anti-shrinking agents, foam regulators, weather-resisting agents, UV radiation absorbers, UV

10   radiation reflectors, infrared radiation absorbers, infrared radiation reflectors, flame retardants, lubricants, colorants, thermal stabilizers, anti-oxidants, crystallization nucleating agents, inorganic fillers, and rubbers, etc., can be suitably mixed into the base resin as

15   necessary.

In the present invention, among the additives noted above, in particular, it is preferable that 0.1 to 15 parts by weight of an anti-shrinking agent be added to 100 parts by weight of the base resin because thereby it is possible

20   to obtain good foam, especially foam exhibiting a high expansion ratio and high thickness.

Citable examples of this anti-shrinking agent include esters of a fatty acid having 10 or more but preferably from 15 to 25 carbons and a polyvalent alcohol having 3 to

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7 hydroxyl groups, fatty acid amines having 10 or more but preferably from 15 to 25 carbons, and fatty acid amides having 10 or more but preferably from 15 to 25 carbons, etc.

For the fatty acid having 10 or more carbons in the

5   anti-shrinking agent noted above, stearic acid, oleic acid, lauric acid, behenic acid, lignoceric acid, cerotic acid, heptaconic acid, montanic acid, melissic acid, and laccelic acid, etc., may be cited, while for the polyvalent alcohol having 3 to 7 hydroxyl groups, glycerin, diglycerin,

10 triglycerin, erythritol, arabitol, xylitol, mannitol, sorbitol, and sorbitan may be cited. For the anti-shrinking agent, moreover, a mixture of two or more anti-shrinking agents may also be used.

Specific examples of anti-shrinking agents that may be

15 cited include glyceryl monostearate, glyceryl monobehenate, glyceryl distearate, glyceryl tristearate, polyoxyethylene myristyl amine, polyoxyethylene palmitin amine, polyoxyethylene stearyl amine, lauric acid amide, myristic acid amide, palmitic acid amide, and stearic acid amide,

20 etc.

Examples of the foam regulator noted above that may be cited include fine powdered forms of such inorganic substances as talc, silica, and clay, etc., and such carbonate or bicarbonate salts as alkali metal salts of

polyvalent carboxylic acid such as sodium hydrogen tartrate, potassium hydrogen succinate, sodium citrate, potassium citrate, sodium bicarbonate, sodium carbonate, and sodium oxalate, etc., which prefer to be added in an amount of

5   0.01 to 10 parts by weight to 100 parts by weight of the base resin.

For the foaming agent used in the manufacture of the extruded open cell foam of the present invention, either a physical foaming agent or a decomposing type foaming agent

10 can be used, but the use of a physical foaming agent is preferred in order to obtain extruded open cell foam of high expansion ratio. For a physical foaming agent, fatty hydrocarbons such as propane, normal butane, isobutane, normal pentane, isopentane, normal hexane, isohexane, and

15 cyclohexane, etc, such chloro-hydrocarbons as methyl chloride and ethyl chloride, such fluoro-hydrocarbons as 1,1,1,2-tetrafluoroethane and 1,1-difluoroethane, etc and such inorganic substances as carbon dioxide, nitrogen, and water, etc may be cited. For a decomposing type foaming

20 agent, azodicarbonamide and the like may be cited. The foaming agents noted above can be used in mixtures of two or more, and a decomposing type foaming agent may be used together with a physical foaming agent and thus serve also to regulate the cell diameter.

The extruded open cell foam of the present invention

prefers to have a density of 15 to 200 kg/m³ and a

thickness of 0.5 to 200 mm, configured either as sheet-form

foam or plank-form foam. Nor is this foam limited to a

5   flat form, but may be configured as rod-shaped foam. The

form of the rod-shaped foam may be cross-sectionally hollow

or cross-sectionally solid. When the extruded open cell

foam of the present invention is sheet-form foam, the

sheet-form foam prefers to have a density of 15 to 200

10   kg/m³ and better still 15 to 60 kg/m³, and a thickness of

0.5 mm or greater but less than 10 mm. The width of the

sheet-form foam prefers to be 45 cm or greater, and more

preferably with 90 cm or greater, and with an upper limit

for the width of 190 cm or so. Sheet-form foam so

15   configured exhibits outstanding flexibility and makes ideal

packaging material. It is also possible to subject this

foam to such processing as bag fabrication or thermoforming

or the like, for use as bags, fruit trays, or other

containers. This foam can be used in a wide variety of

20   applications including partitioning materials obtained by

performing stamping processing or cutting processing on

laminated sheet wherein materials exhibiting shape

retention such as other polypropylene resin foam sheet or

polystyrene resin foam sheet are integrally laminated, and

packaging containers such as fruit packaging materials or precision instrument packaging containers exhibiting high shock-absorption obtained by thermoforming such laminated sheet.

5   When the extruded open cell foam of the present invention is plank-form foam, the density prefers to be 15 to 100 kg/m^3 and the thickness 10 to 200 mm. The width of the plank-form foam should be at least 8 cm, with 25 cm or greater being preferable, and with an upper limit on the

10   width of 150 cm or so. Plank-form foam so configured is ideal for shock absorbing pads, sound absorbing materials, and cushion materials and the like. In particular, when compared to the soft urethane open cell foam used conventionally as a cushion material, the plank-form foam

15   of the present invention exhibits mild compressive strain (the deforming speed being slower than that of ordinary soft urethane), which property is an outstanding property deserving particular mention for applications such as cushion material. This plank-form foam can be made into

20   any desired shape, to suit the application, by stamping processing or cutting processing.

When the extruded open cell foam of the present invention is rod-shaped foam, the density prefers to be 15 to 100 kg/m^3, and the area of the cross-section

perpendicular to the direction of extrusion prefers to be

0.7 cm^2 or greater and more preferably from 1 to 900 cm^2.

When the rod-shaped foam has a hollow cross-section, it is

configured in a cylindrical shape, whereas when the rod-

5 shaped foam has a solid cross-section, it is configured in

a columnar shape. By forming cut creases in the

longitudinal direction of the cylindrically shaped foam,

use as shock-protecting material for pipes and columns and

the like is possible, while the foam of the columnar shape

10 can be used as packing and sealing material, taking

advantage of the delayed restoration property (the fact

that the speed of shape restoration after compression

deformation is slower than that of ordinary soft urethane)

peculiar to such foam. It is also easy to obtain cushion

15 material and the like of large volume by joining the side

surfaces of many rod-shaped foam bodies together.

In the present invention, the thickness and density of

the extruded open cell foam are measured as described below.

That is, for the thickness of the extruded open cell foam,

20 the thickness of the foam is measured at ten points at

equal intervals from one edge to the other edge in the

width dimension, and the arithmetic mean of those ten

points is taken. For the density of the extruded open cell

foam, the weight (g) of a test piece that is 5 cm

longitudinally, 5 cm across, and the thickness of the foam

is measured, the volume (cm^3) of the test piece is next

found from the outer dimensions of the test piece, and the

quotient obtained by dividing the weight (g) of the test

5 piece by the volume thereof is converted to kg/m^3 units.

The extruded open cell foam of the present invention

can be obtained by taking the base resin noted earlier,

such additives as anti-shrinking agents or foaming

regulators such as talc which are added as necessary,

10 supplying those to an extruder, subjecting those materials

to melting under heating and kneading, then supplying a

foaming agent and forming a foaming molten resin mixture,

then regulating the extrusion resin temperature, pressure

inside the extrusion die, and discharge volume, etc., and

15 extruding the mixture from the die attached to the tip of

the extruder into a low-pressure region and causing foaming.

For the method of mixing the components A, B, and C and the

additives, a known method can be adopted such as the method

of dry-blending the mixture components, or the method of

20 using a screw feeder of the like to introduce each of the

mixture components from an extruder raw material supply

port and mixing them together inside the extruder.

By selecting the die attached to the tip of the

extruder according to the shape of the foam intended,

moreover, extruded open cell foam of various shapes can be

manufactured, whether sheet-form foam, plank-form foam, or

rod-shaped foam, etc. If a circular die is attached, for

example, sheet-form foam can be obtained, whereas if a flat

5   die is attached, plank-form foam can be obtained, and if a

die having a hole matching the cross-sectional shape of the

rod bodies is attached, rod-shaped foam can be obtained

that is cylindrical or columnar or the like, but if a many-

holed die is attached, cord-shaped foam or foam having a

10   wide perpendicular cross-section at right angles to the

direction of extrusion wherein multiple rod-shaped foam

body side surfaces are fused together can be obtained, and

if dies of different shape are attached then foam bodies

having different cross-sectional shapes can be manufactured.

15   Also, if necessary, an apparatus (accumulator) may be

installed wherewith the foaming molten resin mixture is

accumulated between the extruder and the die or inside the

die under conditions of high temperature and high pressure,

and, after a prescribed volume has accumulated, that

20   mixture is extruded from the die all at once using a

movable ram. By installing an accumulator, the discharge

speed can be increased dramatically, wherefore, even if the

extruder is small, the foam of the present invention having

high expansion ratio and high thickness can be obtained,

especially foam that is plank-form or rod-shaped.

In the present invention, extruded open cell foam

wherein the open cell foaming ratio is 50% or greater can

5   be formed, as described above, by supplying the base resin

and foaming agent and the like to an extruder, heating,

melting, and kneading those materials to form a foaming

molten resin mixture, and then adjusting the extrusion

resin temperature to be within a suitable foaming

10   temperature range. That is, the foaming molten resin

mixture wherein the extrusion resin temperature has been

adjusted to be within a suitable foaming temperature range

exhibits visco-elasticity that resists the foaming power of

the foaming agent, so that the mixture foams uniformly, and,

15   at the stage where cell walls are formed, the component C

consisting of the polyolefin resin having a melting point

of 120°C or lower and the like cannot follow the stretch of

the component A and component B noted earlier, the

softening point is low compared to the component A and

20   component B, and a decline in visco-elasticity of component

C causes the cell walls to rupture, whereupon open cell

foaming occurs evenly. Even if cell wall destruction

occurs, caused by the reduced visco-elasticity of component

C, the cell shapes themselves are preserved, due to the

sufficient visco-elasticity of the component A. It is

further thought that, in the present invention, the

component B is also contained in the base resin, wherefore

the molten viscosity enhancing effect due to the

5   crystallization of the component B after foaming leads to

an enhancement in the rigidity of the cells that configure

the foam, that in turn results in reinforcing the cell

shape retaining function of the component A, as a

consequence whereof the suitable foaming temperature range

10   wherein the extruded open cell foam is stably obtained is

broadened.

       Specifically, the extrusion resin temperature prefers

to be adjusted within a range of 100 to 140°C, and more

preferably to within a range of 110 to 130°C. When the

15   extrusion resin temperature is below 100°C, the elastic

force of the component A and the component C at the time of

foaming will be too strong, whereupon it has possibility

that extruded open cell foam having a high expansion ratio

can not obtain it.

20   When the extrusion resin temperature exceeds 140°C, on

the other hand, it has possibility that such problems

arising as that the obtained foam will tend to shrink, or

that giant cells will tend to be produced in the foam.

The open cell foaming ratio of the extruded open cell foam can be regulated by such methods as that of selecting the polymer in the component C in the base resin described earlier, that of adding a lubricant to the polymer of the

5   component C, or that of adjusting the viscosity of the component C.

In the present invention, after manufacturing the extruded open cell foam having an open cell foaming ratio of 50% or greater, the open cell foaming ratio of the foam

10 can be raised further by a secondary process such as one employing the method of subjecting the foam to a pin-hole process, piercing it with needles or the like, or one employing the method of destroying cell walls by expansion under heat, or by compression or the like.

15 The present invention is now described in even greater detail with the citation of embodiments.

The densities, melt flow rates, and melting points of the resins and polymers used are noted in Table 1.

The values given in Table 1 for the melt flow rate

20 (MFR) were measured at a temperature of 190°C, under a load of 21.18 N, according to JIS K7210 (1976).

Table 1

	Resin	Product Name	Manufacturer	Density (kg/m³)	MFR (g/10min)	Melting point (°C)
Resin A	Ionomer	Himilan AM7316	DuPont-Mitsui Polychemicals	950	1.3	74.6
Resin B	HDPE	Idemitsu DH 210JZ	Idemitsu Petrochemical	968	5.0	133.6
Resin C	LLDPE	ULTZEX 3550R	Mitsui Petrochemical Industries	935	4.5	123.5
Resin D	PP	Idemitsu PP J700GP	Idemitsu Petrochemical	900	8.0	162.5
Resin E	PP	SUN-ALLOMER PM620A	SunAllomer	900	8.0	149.0
Resin F	LDPE	SUMIKATHENE F101-1	Sumitomo Chemical	922	0.3	110.3
Resin G	LDPE	NUC 8008	Nippon Unicar	917	4.7	107.9
Resin H	EMMA	Acryft WK307	Sumitomo Chemical	940	7.0	76.4
Resin I	EMMA	Acryft WK402	Sumitomo Chemical	940	20.0	73.9
Resin J	VLDPE	EXCELLEN VL EUL731	Sumitomo Chemical	895	10.0	108.6
Resin K	EMAA	NUCREL AN4318	DuPont-Mitsui Polychemicals	940	31.0	78.1

Notes:

5   Ionomer: Ethylene-methacrylic acid-acrylic-acid ester

terpolymer metal salts cross-linked compound

HDPE: High-density polyethylene

LLDPE: Linear low-density polyethylene

PP: Polypropylene homopolymer

LDPE: Low-density polyethylene

EMMA: Ethylene-methyl methacrylate copolymer (ethylene

content = 75%)

VLDPE: Linear very low-density polyethylene

5   EMAA: Ethylene-methacrylic acid copolymer (ethylene

content = 92%)

Embodiment 1

     Raw material obtained by mixing 100 parts by weight of

10   a mixed resin into which were mixed 38 parts by weight of

"resin A," 5 parts by weight of "resin B," and 57 parts by

weight of "resin G," 2 parts by weight of a foaming

regulator master batch in which 5 parts by weight of sodium

citrate and 10 parts by weight of talc were mixed for 100

15   parts by weight of the low-density polyethylene "resin G,"

and 10 parts by weight of an anti-shrinking agent master

batch in which 12 parts by weight of glyceryl monostearate

were mixed for 100 parts by weight of the low-density

polyethylene "resin G," was supplied to a tandem type

20   extruder having a first extruder with a caliber of 50 mm

and a second extruder with a caliber of 65 mm connected by

a crossbar passage, heated, and kneaded to make a molten

resin, after which isobutane was pressure-injected and

kneaded into the resin inside the extruder, as a physical

foaming agent, at a ratio of 8 parts by weight to 100 parts

by weight of the mixed resin, to make the foaming molten

material. Next, the molten material melted and kneaded

inside the extruder was extruded from flat dies having a

5   slit width of 30 mm and slit interval of 3 mm to yield

plank-form extruded open cell foam.

The density, open cell foaming ratio, average cell

diameter, thickness, and width of the foam so obtained were

measured, respectively, and the results indicated,

10   respectively, in Table 2.

Cell Uniformity Evaluation:

○ ··· No giant cells or crushed cells are observed in the

center part of the cross-section of the foam, and

cell shape is uniform.

15   Δ ··· Cell shape in the cross-section of the foam is

unevenness.

× ··· Giant cells or crushed cells are observed in the

center part of the cross-section of the foam.

Manufacturing Stability Evaluation:

20   ○ ··· Density variation across a temperature width of 3°C

or more in the foaming temperature range is less

than 5 kg/m^3, and the variation in open cell foaming

ratio across a temperature width of 3°C or more in

the foaming temperature range is 5% or lower.

x ··· Everything not meeting the criteria noted above.

The average cell diameters given in the table are

5   values arrived at by drawing a straight line crossing the

entire thickness of the foam in the thickness dimension,

based on photographs obtained from cross-sections

perpendicular to the foam extrusion direction or width

dimension, counting the number of cells intersecting that

10 straight line, and dividing the foam thickness (mm) by the

number of cells so obtained.

Table 2

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE (Resin A / Resin B / Resin G)	117	38.8	100	1.28	33.4	100.0	○	
	118	38.5	100	1.30	33.8	100.2	○	○
	119	36.2	100	1.25	35.3	98.4	○	
	120	37.7	100	1.18	35.3	98.3	○	
	121	35.9	100	1.28	35.9	98.3	○	

Embodiment 2

        Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin B," and 57 parts by weight of "resin H." The

density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

10 manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 3.

Table 3

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/EMA (Resin A / Resin B / Resin H)	118	46.2	98	0.93	30.1	97.2	○	
	119	46.7	97	0.95	29.9	95.2	○	○
	120	48.7	98	0.90	29.4	92.4	○	
	121	49.3	99	0.94	29.0	92.2	○	

Embodiment 3

Extruded plank-form extruded open cell foam was
obtained with the same conditions as in Embodiment 1 except
in that 100 parts by weight of mixed resin were made by
5   mixing 38 parts by weight of "resin A," 5 parts by weight
of "resin B," 28.5 parts by weight of "resin F," and 28.5
parts by weight of "resin I." The density, open cell
foaming ratio, average cell diameter, thickness, and width
of the foam so obtained were measured, respectively, the
10 foam cross-sectional cell uniformity and manufacturing
stability were evaluated as noted above, and the results
indicated, respectively, in Table 4.

Table 4

Base Resin	Foaming Conditions	Physical Properties of Foam						Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)			
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	117	34.4	96	1.33	39.1	104.0		○	○
	118	34.3	97	1.30	39.6	101.2		○	
	119	36.8	100	1.23	37.8	101.4		○	
	120	36.0	96	1.25	37.0	99.4		○	
	121	35.6	98	1.32	36.8	96.2		○	

Embodiment 4

Raw material obtained by mixing 100 parts by weight of
a mixed resin into which were mixed 29 parts by weight of
"resin A," 5 parts by weight of "resin B," 38 parts by
5   weight of "resin F," and 28 parts by weight of "resin I," 2
parts by weight of a foaming regulator master batch in
which 5 parts by weight of sodium citrate and 10 parts by
weight of talc were mixed for 100 parts by weight of the
low-density polyethylene "resin G," and 10 parts by weight
10 of an anti-shrinking agent master batch in which 12 parts
by weight of glyceryl monostearate were mixed for 100 parts
by weight of the low-density polyethylene "resin G," was
supplied to a tandem type extruder having a first extruder
with a caliber of 50 mm and a second extruder with a
15 caliber of 65 mm connected by a crossbar passage, heated,
and kneaded to make a molten resin, after which isobutane
was pressure-injected and kneaded inside the extruder, as a
physical foaming agent, at a ratio of 5.8 parts by weight
to 100 parts by weight of the mixed resin, the foaming
20 molten material obtained was filled into and accumulated
inside an accumulator having a caliber of 90 mm connected
downstream from the second extruder, after which the
foaming molten material was extruded all at once, by moving
a movable ram, from the interior of the accumulator,

through flat dies having a slit width of 90 mm and slit

interval of 3mm, to yield plank-form extruded open cell

foam.

The density, open cell foaming ratio, average cell

5   diameter, thickness, and width of the foam so obtained were

measured, respectively, the foam cross-sectional cell

uniformity and manufacturing stability were evaluated as

noted above, and the results indicated, respectively, in

Table 5.

Table 5

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	115	43.7	97	1.27	45.9	267.6	○	○
	116	44.7	96	1.29	45.5	268.4	○	
	117	44.9	98	1.32	45.3	263.0	○	
	118	45.2	98	1.36	45.0	267.4	○	

Embodiment 5

     Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 33.3 parts by weight of "resin A," 16.7 parts by

weight of "resin B," 25 parts by weight of "resin F," and

25 parts by weight of "resin I." The density, open cell

foaming ratio, average cell diameter, thickness, and width

of the foam so obtained were measured, respectively, the

10   foam cross-sectional cell uniformity and manufacturing

stability were evaluated as noted above, and the results

indicated, respectively, in Table 6.

Table 6

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	121	44.8	99	1.20	28.1	93.0	○	○
	122	43.5	98	1.17	29.3	92.2	○	
	123	41.0	99	0.98	30.2	90.2	○	

Embodiment 6

Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 40 parts by weight of "resin A," 3 parts by weight

of "resin B," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin I", and 8.7 parts by weight of

isobutane were pressure-injected and kneaded into 100 parts

by weight of the mixed resin inside the extruder. The

10 density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 7.

Table 7

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMA (Resin A / Resin B / Resin F / Resin I)	120	31.0	95	1.32	43.5	107.6	○	
	121	31.2	96	1.35	43.3	105.5	○	○
	122	33.3	99	1.28	42.2	103.0	○	
	123	33.8	100	1.20	41.7	101.4	○	

Embodiment 7

Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin B," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin I", and 8.7 parts by weight of

isobutane were pressure-injected and kneaded into 100 parts

by weight of the mixed resin inside the extruder. The

10   density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 8.

Table 8

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE /LDPE /EMMA (Resin A / Resin B / Resin F / Resin I)	119	31.4	96	1.39	41.7	109.0	○	○
	120	30.9	96	1.42	42.2	108.4	○	
	121	31.1	97	1.34	42.6	106.4	○	
	122	31.0	99	1.36	43.3	106.2	○	
	123	31.8	99	1.36	42.4	105.4	○	

With Embodiment 7, in a foaming temperature range of

5°C or higher, the change in density is less than 5 kg/m³,

and the change in open cell foaming ratio is 5% or less,

outstanding manufacturing stability is exhibited, no cell

5   crushing is seen in the center of the foam cross-section

such as that seen in Comparative Example 3 (described

subsequently), and outstanding cell uniformity is exhibited.

It is seen that, with Embodiment 7, extruded open cell foam

of low density and high foaming efficiency is obtained,

10   even with the same amount of foaming agent as in

Comparative Example 3.

Embodiment 8

Extruded plank-form extruded open cell foam was

15   obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin C," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin I", and 8.7 parts by weight of

20   isobutane were pressure-injected and kneaded into 100 parts

by weight of the mixed resin inside the extruder. The

density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 9.

Table 9

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LLDPE/LDPE /EVMA (Resin A / Resin C / Resin F / Resin I)	118	41.0	96	1.20	41.0	105.2	○	○
	119	42.0	97	1.27	42.0	104.8	○	
	120	42.9	95	1.34	42.9	103.0	○	
	121	40.3	100	1.22	40.3	102.0	○	

53

Embodiment 9

Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5 mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin D," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin I", and 8.7 parts by weight of

isobutane were pressure-injected and kneaded into 100 parts

by weight of the mixed resin inside the extruder. The

10 density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 10.

Table 10

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /PP/LDPE/ EMMA (Resin A / Resin D / Resin F / Resin I)	119	34.8	97	1.15	38.9	105.0	○	○
	120	34.3	99	1.13	38.6	105.0	○	
	121	36.8	100	1.04	37.1	104.5	○	

Embodiment 10

Extruded plank-form extruded open cell foam was
obtained with the same conditions as in Embodiment 1 except
in that 100 parts by weight of mixed resin were made by
·5   mixing 38 parts by weight of "resin A," 5 parts by weight
of "resin E," 28.5 parts by weight of "resin F," and 28.5
parts by weight of "resin I", and 8.7 parts by weight of
isobutane were pressure-injected and kneaded into 100 parts
by weight of the mixed resin inside the extruder. The
10   density, open cell foaming ratio, average cell diameter,
thickness, and width of the foam so obtained were measured,
respectively, the foam cross-sectional cell uniformity and
manufacturing stability were evaluated as noted above, and
the results indicated, respectively, in Table 11.

Table 11

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /PP/LDPE/ EMMA (Resin A / Resin E / Resin F / Resin I)	118	40.5	96	1.02	32.0	102.2	○	○
	119	38.3	100	1.08	33.9	100.0	○	
	120	37.9	100	1.12	34.4	100.2	○	

Embodiment 11

        Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 29 parts by weight of "resin A," 5 parts by weight

of "resin B," 37 parts by weight of "resin F," and 29 parts

by weight of "resin G." The density, open cell foaming

ratio, average cell diameter, thickness, and width of the

foam so obtained were measured, respectively, the foam

10 cross-sectional cell uniformity and manufacturing stability

were evaluated as noted above, and the results indicated,

respectively, in Table 12.

Table 12

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /LDPE (Resin A / Resin B / Resin F / Resin G)	117	42.9	92	1.23	29.2	99.0	○	○
	118	43.8	93	1.19	28.9	98.0	○	
	119	47.6	96	1.12	26.9	94.0	○	

Embodiment 12

Extruded plank-form extruded open cell foam was obtained with the same conditions as in Embodiment 1 except in that 100 parts by weight of mixed resin were made by

5   mixing 38 parts by weight of "resin A," 5 parts by weight of "resin B," 28.5 parts by weight of "resin F," and 28.5 parts by weight of "resin J." The density, open cell foaming ratio, average cell diameter, thickness, and width of the foam so obtained were measured, respectively, the

10   foam cross-sectional cell uniformity and manufacturing stability were evaluated as noted above, and the results indicated, respectively, in Table 13.

Table 13

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /VLDPE (Resin A / Resin B / Resin F / Resin J)	119	34.8	92	1.27	36.8	97.4	○	
	120	35.2	93	1.23	36.3	96.2	○	○
	121	39.0	96	1.17	33.7	94.2	○	

Embodiment 13

Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

5   mixing 38 parts by weight of "resin A," 5 parts by weight

of "resin B," 28.5 parts by weight of "resin F," and 28.5

parts by weight of "resin K." The density, open cell

foaming ratio, average cell diameter, thickness, and width

of the foam so obtained were measured, respectively, the

10   foam cross-sectional cell uniformity and manufacturing

stability were evaluated as noted above, and the results

indicated, respectively, in Table 14.

Table 14

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /HDPE/LDPE /EMAA (Resin A / Resin B / Resin F / Resin K)	115	33.4	67	0.81	39.5	110.0	○	
	116	33.1	68	0.79	39.7	110.2	○	
	117	32.9	68	0.82	39.8	108.2	○	○
	118	33.2	68	0.95	40.2	108.0	○	
	119	33.0	68	0.93	40.4	108.0	○	
	120	33.4	70	0.90	40.3	106.2	○	
	121	33.6	71	0.92	40.6	104.0	○	

Comparative Example 1

        Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

 5   mixing 43 parts by weight of "resin A," and 57 parts by

weight of "resin G." The density, open cell foaming ratio,

average cell diameter, thickness, and width of the foam so

obtained were measured, respectively, the foam cross-

sectional cell uniformity and manufacturing stability were

10   evaluated as noted above, and the results indicated,

respectively, in Table 15.

Table 15

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE (Resin A / Resin G)	115	37.7	100	1.41	34.9	101.4	△	
	116	38.6	100	1.38	36.7	100.0	△	○
	117	36.5	100	1.43	37.5	99.6	△	

   With Comparative Example 1, in a foaming temperature

range of 3°C or higher, the change in density is less than

5 kg/m^3, and the change in open cell foaming ratio is 5% or

less.   However, with Embodiment 1 that temperature range is

5 broadened to 5°C or greater, and Embodiment 1 is recognized

as exhibiting more outstanding manufacturing stability.

Also, although the foam obtained in Comparative Example 1

is usable as a product, cell unevenness is observed very

locally in the foam cross-section, wherefore the foam of

10 Embodiment 1 exhibits more outstanding cell uniformity.

Comparative Example 2

   Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

15 in that 100 parts by weight of mixed resin were made by

mixing 43 parts by weight of "resin A," 28.5 parts by

weight of "resin F," and 28.5 parts by weight of "resin I."

The density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

20 respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 16.

Table 16

Base Resin	Foaming Conditions		Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type		Foaming Temperature (℃)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE/EMA (Resin A / Resin F / Resin I)		115	36.0	86	1.26	40.9	102.4	○	
		116	41.9	98	0.98	36.1	100.4	○	×
		117	50.4	100	–	32.6	91.2	×	
		118	60.8	100	–	27.3	84.0	×	

("—" in table indicates no measurement made)

Comparative Example 2 is a comparative example for

Embodiment 3. With Comparative Example 2, in a foaming

temperature range of 3°C, the change in density is 5 kg/m³

or greater, manufacturing stability is lacking, and cell

5 crushing was observed in the center of the cross-section of

the foam obtained at a foaming temperature of 117°C or

higher.

Comparative Example 3

10   Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

mixing 43 parts by weight of "resin A," 28.5 parts by

weight of "resin F," and 28.5 parts by weight of "resin I,"

15 and 8.7 parts by weight of isobutane were pressure injected

and kneaded into 100 parts by weight of the mixed resin

inside the extruder. The density, open cell foaming ratio,

average cell diameter, thickness, and width of the foam so

obtained were measured, respectively, the foam cross-

20 sectional cell uniformity and manufacturing stability were

evaluated as noted above, and the results indicated,

respectively, in Table 17.

Table 17

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE/EMMA (Resin A / Resin F / Resin I)	117	31.8	76	1.68	43.9	102.0	○	×
	118	34.5	85	1.42	37.2	101.4	○	
	119	41.7	100	1.03	34.0	91.8	○	
	120	41.4	100	—	34.9	88.0	×	
	121	49.4	100	—	31.6	82.0	×	

("—" in table indicates no measurement made)

Comparative Example 3 is a comparative example for

Embodiment 7. With Comparative Example 3, in a foaming

temperature range of 3°C, the change in density is 5 kg/m^3

or greater, manufacturing stability is lacking, and cell

5   crushing was observed in the center of the cross-section of

the foam obtained at a foaming temperature of 120°C or

higher.

Comparative Example 4

10   Extruded plank-form extruded open cell foam was

obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

mixing 34 parts by weight of "resin A," 37 parts by weight

of "resin F," and 29 parts by weight of "resin G." The

15   density, open cell foaming ratio, average cell diameter,

thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 18.

Table 18

Base Resin	Foaming Conditions	Physical Properties of Foam					Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)		
Ionomer /LDPE/LDPE (Resin A / Resin F / Resin G)	116	30.6	38	1.89	39.3	100.6	○	×
	117	40.2	78	—	33.4	97.0	△	
	118	48.2	95	—	25.5	92.2	△	
	119	57.6	100	—	19.5	80.6	△	

("—" in table indicates no measurement made)

Comparative Example 4 is a comparative example for

Embodiment 11. With Comparative Example 4, in a foaming

temperature range of 3°C, the change in density exceeds 5

kg/m³, manufacturing stability is lacking, and portions of

5   cell unevenness were observed in the cross-section of the

foam obtained at a foaming temperature of 117°C or higher.

Comparative Example 5

Extruded plank-form extruded open cell foam was

10   obtained with the same conditions as in Embodiment 1 except

in that 100 parts by weight of mixed resin were made by

mixing 43 parts by weight of "resin A," 28.5 parts by

weight of "resin F," and 28.5 parts by weight of "resin J."

The density, open cell foaming ratio, average cell diameter,

15   thickness, and width of the foam so obtained were measured,

respectively, the foam cross-sectional cell uniformity and

manufacturing stability were evaluated as noted above, and

the results indicated, respectively, in Table 19.

Table 19

Base Resin	Foaming Conditions	Physical Properties of Foam						Cell Uniformity	Manufacturing Stability
Mixed Resin Type	Foaming Temperature (°C)	Density (kg/m³)	Open Cell Foaming Ratio (%)	Average Cell Diameter (mm)	Thickness (mm)	Width (mm)			
Ionomer /LDPE/VLDPE (Resin A / Resin F / Resin J)	117	34.7	92	1.47	39.3	98.0		○	✕
	118	42.4	98	0.90	33.4	90.0		○	
	119	60.3	100	0.62	25.5	68.6		✕	

Comparative Example 5 is a comparative example for

Embodiment 12.   With Comparative Example 5, in a foaming

temperature range of 3°C, the change in density is 5 kg/m^3

or greater, manufacturing stability is lacking, and cell

5   crushing was observed in the center of the cross-section of

the foam obtained at a foaming temperature of 119°C or

higher.

Comparative Example 6

10   An attempt was made to obtain rod-shaped extruded open

cell foam with the same conditions as in Embodiment 1

except in that 100 parts by weight of mixed resin were made

by mixing 5 parts by weight of "resin B," 67 parts by

weight of "resin F," and 28 parts by weight of "resin H,"

15   and in that the die was made 4mm φ rod die, but no foam was

obtained.

Below, the compressive strengths of the foams obtained

in Embodiments 6 to 9 and Comparative Example 3 are given

in Table 20, and the defection set by constant compression

20   and defection set by repeated compressions of the foams

obtained in Embodiments 6 to 10 and Comparative Example 3

are given in Tables 21 and 22, respectively.   The methods

of testing for compressive strength and permanent

compressive strain were as described below.

Compressive strength:

Static compression tests were performed in accordance

5   with JIS Z0234 (1976) Method A. The dimensions of the test

pieces were made 50 mm longitudinally × 50 mm across × the

thickness of the foam and the load speed was made 10

mm/minute. After compressing the test piece to 80% of its

thickness, the compression was released at the same speed

10   as the load speed, and measurement was concluded at the

point in time where the compressive stress became 0 Pa, to

yield a stress-strain curve. The loads at the time of 5%

compression and at the time of 25% compression,

respectively, were read from the curve obtained, and the 5%

15   compressive strength and 25% compressive strength were

calculated therefrom.

Defection set by constant compression:

Except in that the conditions of the test atmosphere

were made 23°C temperature and 50% relative humidity,

20   defection set by constant compression tests were performed

according to JIS K6401 (1980). The dimensions of the test

pieces were made 50 mm longitudinally × 50 mm across × the

thickness of the foam. The test piece was compressed to

50% and left standing in that condition for 22 hours, after

which the compression was released. The thickness of the

test piece was then measured, 30 minutes later and 24 hours

later, respectively, and the percentage of defection set by

5 constant compression was calculated.

Defection set by repeated compressions:

Except in that the conditions of the test atmosphere

were made 23°C temperature and 50% relative humidity,

defection set by repeated compressions tests were performed

10 according to JIS K6401 (1980). The dimensions of the test

pieces were made 50 mm longitudinally × 50 mm across × the

thickness of the foam. The test piece was subjected to

80,000 continuously repeated compressions to 50% of the

thickness thereof, at a speed of 60 revolutions/minute.

15 Then the thickness of the test piece was measured, 30

minutes and 24 hours after the compression was released,

respectively, and the percentage of defection set by

repeated compressions was calculated therefrom.

Table 20

	5% Compressive Strength (kPa)	25% Compressive Strength (kPa)
Embodiment 6	5.16	9.41
Embodiment 7	6.09	10.36
Embodiment 8	4.32	8.21
Embodiment 9	5.91	10.37
Comparative Example 3	4.45	7.66

5

Table 21

	Percentage of defection set by constant compression After 30 Minutes(%)	Percentage of defection set by constant compression After 24 Hours(%)
Embodiment 6	6.8	2.0
Embodiment 7	7.4	2.2
Embodiment 8	4.4	2.3
Embodiment 9	6.1	1.8
Embodiment 10	4.9	1.1
Comparative Example 3	3.4	1.0

Table 22

	Percentage of defection set by repeated compressions After 30 Minutes(%)	Percentage of defection set by repeated compressions After 24 Hours(%)
Embodiment 6	10.7	3.8
Embodiment 7	10.9	4.5
Embodiment 8	9.0	3.1
Embodiment 9	8.3	2.6
Embodiment 10	7.8	2.4
Comparative Example 3	5.4	2.8

5   INDUSTRIAL APPLICABILITY

The extruded polyolefin resin foam of the present

invention exhibits a high expansion ratio, uniform cell

diameter, and outstanding mechanical properties, and is

well suited for use as cushion material, packaging material,

10   sound absorbing material, water absorbing material, anti-

vibration material, and various types of industrial filter.

CLAIMS

1.   An extruded polyolefin resin foam, characterized in that said extruded polyolefin resin foam is an extruded

5   foam exhibiting an open cell ratio of 50% or greater, and that base resin thereof is principally composed of a mixed polymer consisting of 4.5 to 75 parts by weight of component A consisting of an ethylene ionomer resin, 0.5 to 30 parts by weight of component B consisting of a

10   polyolefin resin having a melting point exceeding 120°C, and 20 to 95 parts by weight of component C consisting of one or two or more polymers selected from a group of ethylene-propylene rubbers, styrene elastomers, and polyethylene resins having melting points of 120°C or lower

15   (where component A + component B + component C = 100 parts by weight).

2.   The extruded polyolefin resin foam according to claim 1, characterized in that said component B consisting of a polyolefin resin having a melting point exceeding

20   120°C is one type or a mixed resin of two or more types selected from among polypropylene resin, linear low-density polyethylenes, and polyethylene resins having a density of 940 kg/m^3 or greater.

3.   The extruded polyolefin resin foam according to
claim 1, characterized in that said polyethylene resin
having a melting point of 120°C or lower in said component
C is one type or a mixed resin of two or more types
5   selected from among low-density polyethylenes, ethylene-α
or β unsaturated carboxylic acid copolymers (but excluding
ionomers), and ethylene-vinyl acetate copolymers.

4.   The extruded polyolefin resin foam according to
claim 1, characterized in that 0.1 to 15 parts by weight of
10 an anti-shrinking agent are added to 100 parts by weight of
said base resin.

5.   The extruded polyolefin resin foam according to
claim 1 or claim 4, characterized in that said extruded
foam has a density of 15 to 200 kg/m^3 and a thickness of
15 0.5 to 200 mm.

6.   The extruded polyolefin resin foam according to
claim 1 or claim 4, characterized in that said extruded
foam is sheet-form foam or plank-form foam.

7.   The extruded polyolefin resin foam according to
20 claim 1 or claim 4, characterized in that said extruded
foam is rod-shaped foam having a density of 15 to 100 kg/m^3,
and area of vertical cross-section thereof orthogonal to
direction of extrusion being 0.7 cm^2 or greater.